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EVALUATION OF COMMERCIAL ACRYLIC FIBER FOR USE IN COMBUSTIBLE CARTRIDGE CASES

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A production method was developed to fibrillate commercial acrylic fiber suitable for the manufacture of combustible cartridge cases.

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Acknowledgment is made for the cooperation received from American Cyanamid Company personnel in furnishing fiber samples, for their evaluation of treated acrylic fibers following experimentation, and for the interest shown by them during the progress of this program.

SUMMARY

This program was designed to develop a method or methods for the fibrillation of commercial acrylic fiber for use in the manufacture of combustible cartridge cases.

Various conditions of refining were examined with the use of a fibrillator or "deflaker." Also included in the study were various types of acrylic fibers.

The approach found to be successful was that of pre-swelling the fiber (Creslan, type 98, manufactured by American Cyanamid Company) in an aqueous solution of sodium thiocyanate, with subsequent mechanical fibrillation and washing.

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INTRODUCTION

During the early 1950s, a program was undertaken at Picatinny Arsenal to develop substitutes for silk cartridge cloth.[1] Silk, then required for cartridge bags for artillery propellant charges, is a material of foreign production. Thus, during a time of conflict, silk is extremely difficult, if not impossible, to obtain.

At the time that domestic, low-cost fibers were being sought, new synthetic fibers appeared on the commercial market. These fibers, to replace the silk cartridge cloth, required unique chemical properties. First, these new cloths had to be compatible with single-, double-, and triple-base propellants; that is, the cloth could have no deleterious effect on the propellant. Also, these cloths (fibers) had to be resistant to degradation by the oxides of nitrogen, which are slowly given off by propellant (nitrocellulose or nitrocellulose/nitroglycerin) during long-term storage. When subjected to moisture, the oxides of nitrogen form nitric and/or nitrous acids which cause hydrolytic degradation of many fibers. If cartridge bags containing propellant deteriorate and the propellant is spilled, the charge will no longer be serviceable. Also, a hazard could be created.

Accelerated aging tests and long-term storage tests were conducted on nylon, cotton, rayon, acetate, and acrylic cloths which had been in contact with the various types of propellants at various elevated temperatures and humidities. Silk cloth was always used as a reference sample during testing.

Cloth of acrylic gave superior results. Comparison of tensile strength values before and after exposure showed acrylic cloth to be unaffected. Nylon, cotton, rayon, and acetate were found to be unsatisfactory because they deteriorated after exposure. Silk deteriorated only slightly since it is amphoteric and could act as an acid or base.

Another advantage of acrylic fiber for cartridge cloth is that it does not exhibit the property of "afterglow"; that is, when the cloth has burned and has been extinguished, the residue does not glow. This precludes the pre-ignition of the subsequent charge to be loaded into the weapon. Other advantages include low moisture pick-up and burning to a brittle, carbonaceous ash which is blown out of the gun during firing.

It was also found that blends of fibers (acrylic plus rayon) containing over 50% acrylic fiber offered satisfactory protection against degradation. By legal definition, a textile fiber, to be called "acrylic," must have a minimum of 85% polyacrylonitrile.

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[1] I. G. Nadel and J. S. Musgrave, "Develop Substitute Cartridge Cloth Material," PA Technical Division Report No. 1916, Picatinny Arsenal, Dover, NJ, 10 February 1953.

A number of combustible components used in several ammunition items are manufactured by a pulp-molding (felting) process. This process consists of slurrying fibers with a resin emulsion in water, and the resin then being precipitated onto the fibers. This mixture, diluted with a large volume of water, is drawn by vacuum onto a screened hollow form. The fiber resin mixture is then deposited on the screen with the water passing through. This fibrous mat, or preform, is removed and is placed between heated matched metal molds where it is dried and cured. Subsequently, the part is trimmed to final dimensions. Appendix A, prepared by Armtec, details this process.

During the development of combustible cartridge cases by the pulp-molding or felting technique, it was reasoned that the inclusion of an acrylic fiber into case compositions would be ideal. However, the textile acrylic fibers available at that time (early 1960s) had no web-forming properities and, consequently, could not be used. As the program continued, it was learned that a special acrylic fiber had been developed by the American Cyanamid Company for use in paper-making.

The fiber, Creslan type 98 (T-98), was furnished water-wet in a swollen or gel state and had to be refined in a beater or "deflaker" (fibrillator) to produce web-forming properties with the appropriate drainage rate for the specific end items (fig. 1). [A typical deflaker that was manufactured by Sprout, Waldron & Co. (now Koppers Co., Inc.) is described in appendix B.] Creslan T-98 is fibrillated prior to use in the slurry. Fibrillation is a process whereby fibers are mechanically treated to impart web-forming properties to the fibers. Those properties help to bind the various fibers together into a web, or "felt," resulting in satisfactory mechanical properties of the finished item.

Creslan T-98 eventually became part of the combustible cartridge case development, and was finally placed into production of 152-mm cartridge cases, as well as igniter tubes for large caliber artillery ammunition.

After several years of marketing Creslan T-98, American Cyanamid found that sales were not sufficient to continue with this fiber and suspended production. Prior to production shutdown, the U.S. Government purchased large quantities of this fiber for use until a new web-forming acrylic fiber could be developed.

The program described in this report is that development, contracted to EFMC Corporation, now Armtec Defense Products, Inc.

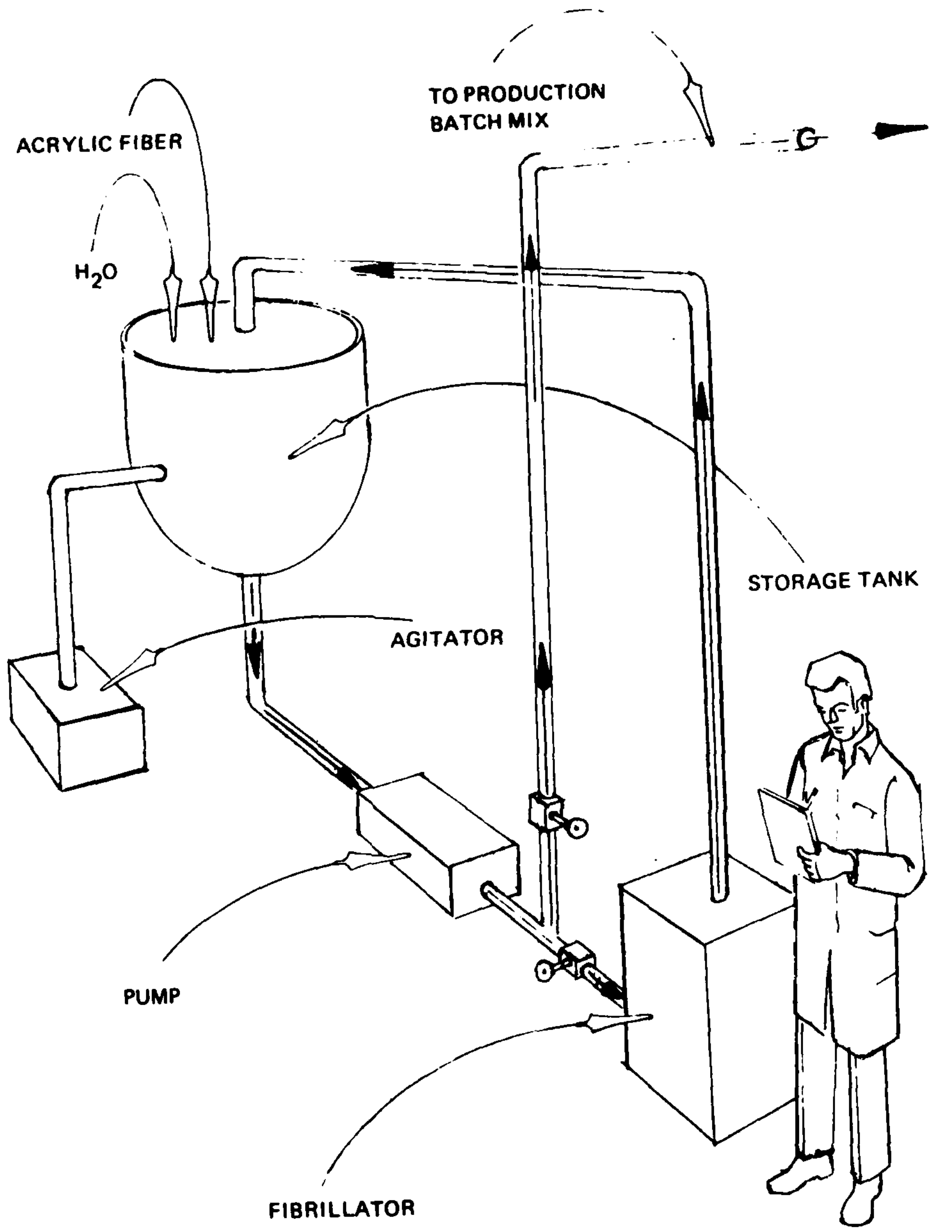


Figure 1. Fibrillation Flow Chart

FIBER IDENTIFICATION

In preparation for this study of Fibrillation Tasks, it became necessary to identify the fibers and to visually establish the fibrillated acrylic fiber apart from the other fibers in the formulation.

The three fibers used in the slurry are identified in figure 2:

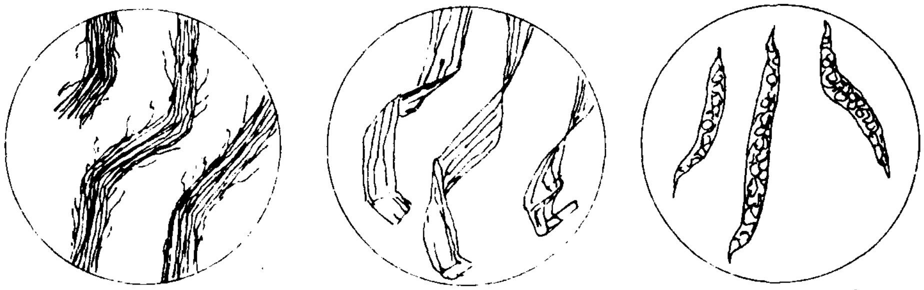


Figure 2. Fiber identification magnified

Additional views of the fibers in slurry depict the formulation in the process of the resin precipitation sequence (figs. 2 through 21).

Figure 3. 80X View Acrylic Fibers

Figure 4. 320X View Acrylic Fibers

Figure 5. 80X View Kraft

Figure 6. 320X View Kraft

Figure 7. 80X View Acrylic, Kraft, and Nitrocellulose

Figure 8. 80X View After Addition of Lufax 295

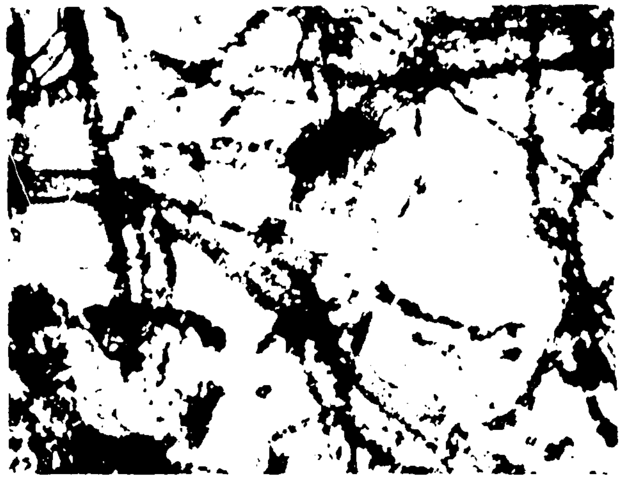


Figure 9. 80X View 5 Minutes After Addition of Resin.
(Note fuzzy effect around fibers indicating the attraction of resin to fibers.)

Figure 10. 80X View 10 Minutes After Addition of Resin.
At this point all the resin appears to be on or around the fibers.

Figure 11. 80X View 15 Minutes After Addition of Resin. (Note heavy concentration of precipitated resin on fibers.)

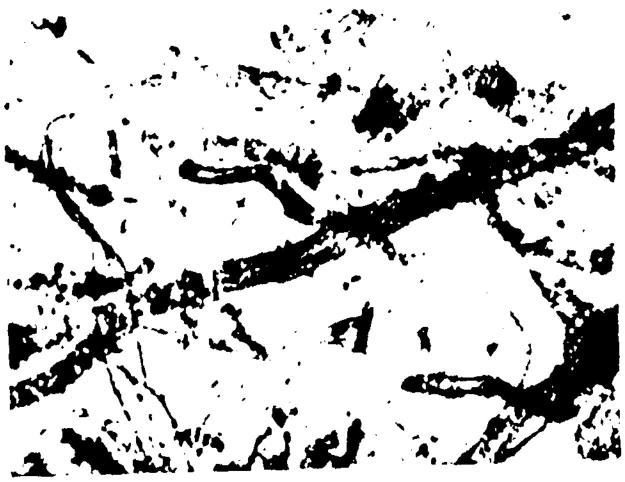


Figure 12. 80X View 20 Minutes After Addition of Resin. This view shows little difference from the 15 minute slide other than a tightening effect of the resin precipitation.

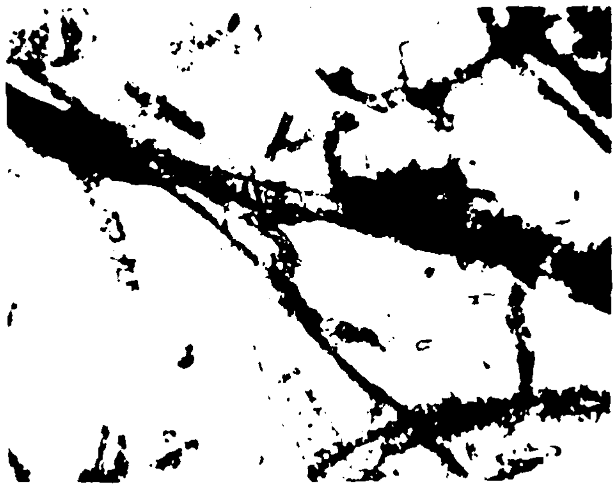
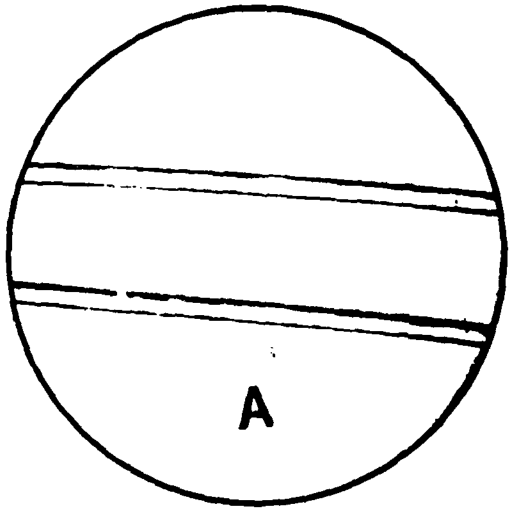


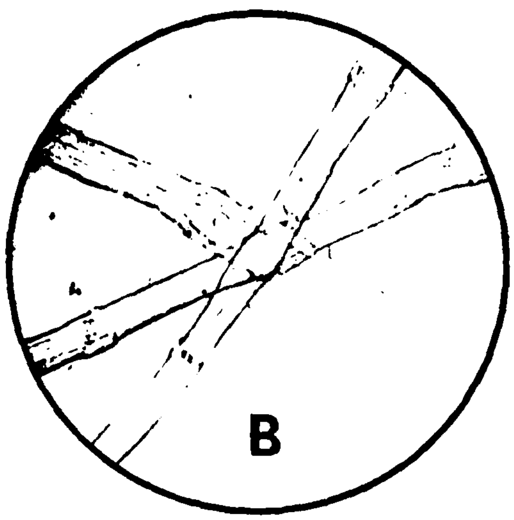
Figure 13. 80X View 30 Minutes After Addition of Resin.
This view shows very clean tight concentrations of resin on the fibers.

Figure 14. 320X View of Resin Precipitation on an Acrylic Fiber.



Dry commercial acrylic as received, and with no attempt at fibrillation.

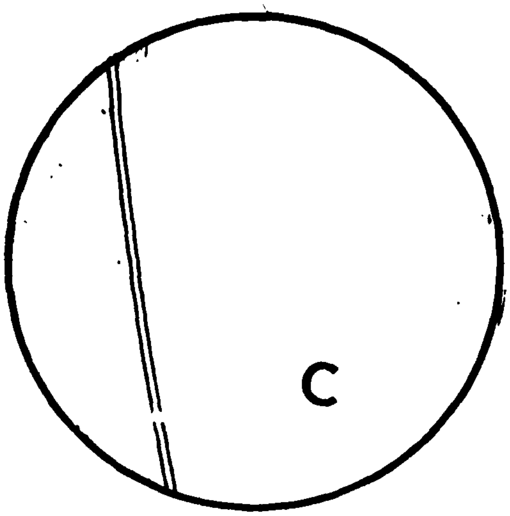
Figure 15



Same material after a normal process attempt at fibrillation.

RESULTS:
Unacceptable, not usable.

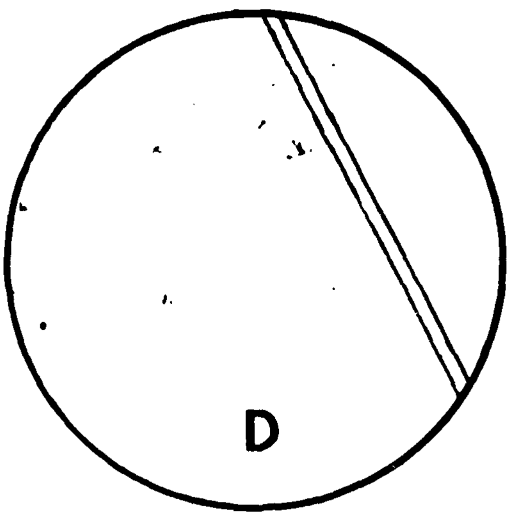
Figure 16



Experiment #24

Acrylic fiber as received and with no attempt at fibrillation.

Figure 17



Experiment #24

Same material after 10 minutes wetting in the "solution," and prior to fibrillation attempt.

Figure 18

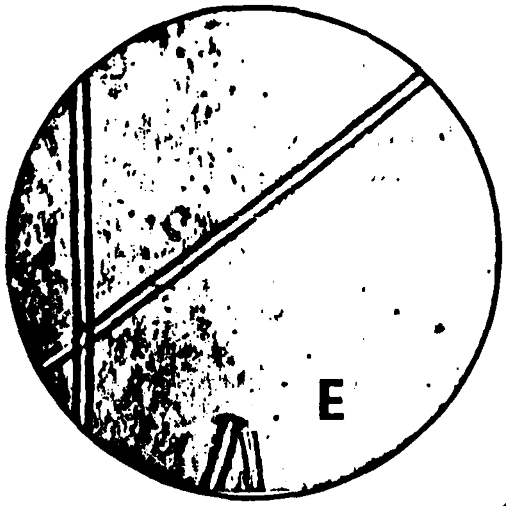


Figure 19

Same material after 60 minutes wetting in the "solution." No additional swelling.

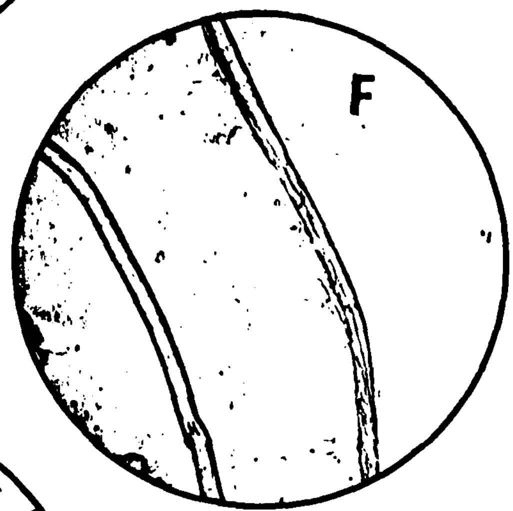


Figure 20

Same material. First attempt at fibrillation. .006 gap, 5 minute fibrillation.

RESULTS: Fair.

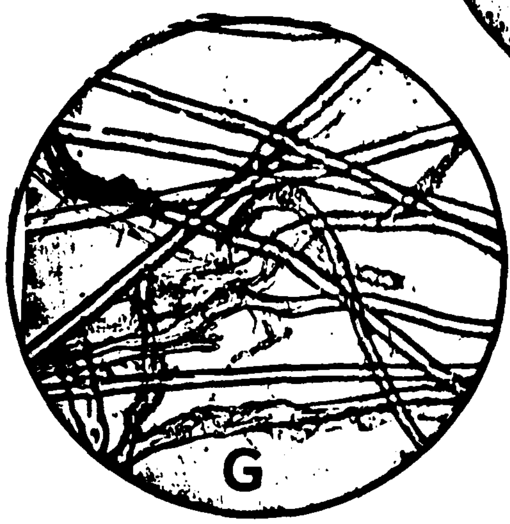


Figure 21

Same material with continued fibrillation for 5 minutes.

RESULTS: Good.

FIBRILLATION TASKS

Summary

During the contract period, 24 separate experiments were performed applicable to the fibrillation process; nine experiments resulted in actual molding attempts. Three hundred cartridge cases and 100 igniter tubes were produced in accordance with contractual requirements.

The fibrillatable acrylic fiber (MIL-F-50250) used for combustible cases and igniters is a special "gel state" fiber.

The tasks performed under this study were accomplished on a model D3710-603 Deflaker, manufactured by Sprout, Waldron and Company of Muncy, Pennsylvania, and utilizing specific type facing plates to perform the actual fiber altering (plate type, 9 inch, D16A007 Nl-Hard). The only adjustment variables during the process were the pressure of the liquid feed and the gap of the adjustable plates.

Creslan acrylic fiber is experiment 24 was fibrillated successfully after swelling (with a 40% aqueous solution of sodium cyanate).

Results of the 24 fibrillation tasks are summarized in table 1.

Experiment 1

Material Used

American Cyanamid Creslan, type 61, 5 denier, regular shrink, 1.5-inch unchopped length.

Operation A

The raw dry acrylic material (31 lb) was added to water (3,700 lb) and dispersed for 7 minutes, at which time it was concluded that adequate fiber separation had taken place.

Operation B

The wetted acrylic and its water were then transferred by pump to the fibrillation holding tank. The agitator propeller and mixing blades were run at maximum speed during the transfer.

Table 1. Summary -- Tasks 1 through 24

Experiment	Fiber type[a]	Fiber Length (in.)	Premix time	Gap (in.)	Back pressure (lb)	Temp (°F)	Fibrillation results	Rate drain (sec)	Parts produced
1	A	1 1/2	7 min	0.100 to 0.006	NS[b]	75	Knotting and tangling	ND[c]	None
2	A	3/8	1 hr	0.010	NS[b]	75	Poor	11.6	None
3	A	NS[b]	2 hrs	0.010	NS[b]	74	30 to 40% satisfactory	10.9	None
4	A	3/8	2 hrs	0.016	NS[b]	75	Poor	ND	None
5	A	3/4	2 hrs	0.014	NS[b]	78	Improved	11.0	None
6	A	3/4	1 hr 10 min	0.012	NS[b]	NS[b]	80% satisfactory	ND[c]	Yes--worthy of re-study
7	A	3/4	1 hr 15 min	0.010	25/30	78	Poor	8.3	None
8	D	3/4	1 hr plus	0.008	25/30	78	Poor	1.1	None
9	D	3/4	1 hr	0.008	40/45	82	Improved	3.4	Poor quality
10	D	3/4	1 hr	0.008	25/30	74	Fair fibrillation	1.3	None

[a] Types:
A = American Cyanamid, "Creslan," 5 denier, hi-shrink.
A 1.5 = American Cyanamid, "Creslan," 1.5 denier, standard shrink.
D = duPont, "Orlon," 5 denier, regular shrink.
M = Monsanto, "Acrilan," 5 denier, regular shrink.

[b] Not specified.

[c] Not determined.

[d] This experiment was initiated to examine the feasibility of chemically "pre-swelling" the acrylic prior to mechan[illegible] fibrillation. Sodium thiocyanate solution was used as the swelling agent.

Table 1. (cont)

Experiment	Fiber type[a]	Fiber Length (in.)	Premix time	Gap (in.)	Back pressure (lb)	Temp (°F)	Fibrillation results	Rate drain (sec)	Parts produced
11	D	3/4	1 hr	0.006	25/30	76	Good fibrillation, fines excessive	1.8	None
12	M	3/4	1 hr	0.006	20/25	78	Very good fibrillation	2.4	None
13	M	3/4	1 hr	0.006	20/25	74	Same as experiment 12	2.7	None
14	A	NS[b]	1 hr	0.006	35	76	Good, fines excesive	2.5	None
15	D	3/4	1 hr	0.006	20/25	74	Aborted due to pump failure		None
16	A	3/4	1 hr	0.006	14/17	NS[b]	Rerun for additional 10 *min* produced good fibrillation	5.1	Unacceptable
17	A	3/4	1 hr	0.012	20/25	76	65% acceptable	5.3	Low quality, unacceptable
18	A	3/4	1 hr	0.012	15/20	73	Due to unwetted fibers, the material was rerun without improvement		None
19	A	3/4	1 hr	0.010	15	NS[b]	Sufficient after 3 cycles	4.1	Acceptable with the exception of minor separations
20	A 1.5	3/4	1 hr	0.006	15	77	Good, with some knotting	5.7	Good quality, with some soft spots
21	A 1.5	3/4	1 hr	0.010	15	74	Less breakage but still ~12% untouched fibers	1.8	Poor quality, incomplete binding
22	A	3/4	1 hr	0.006	20	74	Minimum acceptable fibrillation	2.6	Poor quality
23	A	3/4	1 hr	0.010	15/20	75	Fair fibrillation	5.4	None
24[d]	A	NS[b]	1 hr	.006 and .004	NS[b]	NS[b]	Swelling was at maximum in 15 minutes		Excellent--completes intent of contract

Operation C

The fibrillator (model D3710-603 deflaker by Sprout, Waldron & Company) was turned on with a center line refiner plate gap of 0.100 inch (plate type, 9 inch, D16A007, NI-hard, staggered type).

Operation D

The fibrillation process was started at a water temperature of 75°F (23.89°C). Circulation of fiber and water was accomplished through the fibrillator. Observation and sample analysis showed no fibrillation, but much tangling and knotting.

Operation E

The gap setting was gradually reduced to 0.006 inch, at which time extreme knotting and roping was apparent. Fiber plugs appeared and the pumping of fiber through the fibrillator stopped. Subsequent dismantling of the pump and fibrillator revealed a complete and solid plug of fused and knotted fiber.

Operation F

The slurry of water and fiber was removed and the equipment was cleaned of all residual fibers. The fiber was discarded and the experiment was concluded.

Conclusion

Fibrillation of commercial fiber at the normal length (1.5 in.) is not feasible with the use of existing fibrillation methods and equipment.

Experiment 2

Material Used

American Cyanamid Creslan, type X-61M, 5 denier, hi-shrink.

Operation A

The raw material (31 lb) was cut to the 3/8-inch length (same length as existing acrylic) per specification MIL-F-50809. The acrylic was added to the normal quantity of water (3,700 lb) and wetted by agitation until examination of fibers indicated a wet condition similar to specification material. (Specification acrylic dry and bulk-packed.)

Operation B

The wetted fibers were then transferred to the fibrillator holding tank. The agitator propeller and mixing blades were run at normal speed.

Operation C

The fibrillation process was begun with normal gap tolerance, utilizing refiner plates of type and condition used in normal fibrillation procedures [gap, 0.010 in.; water temperature, 75°F (23.89°C)]. The first pass at fibrillation, 30 minutes, resulted in fibers that, by microscopic analysis, were approximately 60% hit. Some fibrillation was apparent, but complete breaks of fiber were in excess of normal specification fiber.

Operation D

The material was then reprocessed at the same gap setting for an additional 5 minutes. The water temperature increased to 88°F (31.11°C). Microscopic examination of samples disclosed that fiber fibrillation was extreme, resulting in broken and chopped fibers of the following classifications:

8 mesh: 41.8%; 14 mesh: 9.3%; 48 mesh: 38.6%; 100 mesh: 10.3%.

The drainage rate (ref. TAPPI Standard T-1002 SU-60) was 11.6 seconds.

Conclusion

Material as fibrillated should be stored for possible use on a test basis. The drainage rate indicates a better fibrillation than shown by actual visual examination. Further experiments should be made in the comparison of visual (microscopic) and drainage rate requirements.

Experiment 3

Material Used

American Cyanamid Creslan, type X-61M, 5 denier, hi-shrink.

Operation A

Raw material used was 31 pounds. The dry fiber was added to the normal water quantity (3,700 lb) and wetted twice the normal time span of experiment 2 (2 hours versus 1 hour). Examination of the wet fibers did not reveal a marked difference from experiment 2, and again showed a good similarity to the specification-type acrylic.

Operation B

Samples of specification acrylic and of the experiment 3 acrylic (post Operation A) were dried and examined by microscope. No marked difference was apparent except for a slightly duller finish on the specification acrylic.

Operation C

The wet fiber and accompanying water were then transferred to the fibrillator holding tank. The agitator propeller and mixing blades were run at normal speed.

Operation D

The fibrillator process was begun at the normal gap tolerance (0.010) and the fiber was processed for 40 minutes. At the end of the 40-minute time span, some fibrillation (20%) was visually evident but the majority of fibers were still smooth. An additional 15 minutes' fibrillation was completed at the normal 0.010 gap tolerance. The water temperature was increased to 89°F (31.66°C) [from 74°F (23.33°C)]. The fibrillation process was then stopped due to the breaking of fibers. Examination of fibers indicated a 30 to 40% satisfactory fibrillation. The remaining fibers were in process of breaking due to "kinks" and "canes." The following classification of fiber length indicates the condition of the fibers:

8 mesh: 67.6%; 14 mesh: 4.2%; 48 mesh: 20.5%; 100 mesh: 7.7%.

The drainage rate (ref. TAPPI Standard T-1002 SU-60) was 10.9 seconds.

Conclusion

The fibers have a possible use in the manufacturing process. The material will be labeled and stored for use only as a test experiment. The fiber as fibrillated is below all standards used in existing production in accordance with MIL-F-50809.

Experiment 4

Material Used

American Cyanamid Creslan, type 61, 5 denier, regular shrink, 3/8-inch length.

Operation A

Raw material used was 31 pounds. The dry fiber was added to an increased water quantity (5,000 lb versus 3,700). The wetting time remained 2 hours (per experiment 3). Visual examination indicated an acceptable condition of wetness and separation of fibers.

Operation B

The wet fibers were transferred to the fibrillator holding tank. The agitator propeller and blades were run at a 20% increase.

Operation C

Fibrillation was begun with an increased gap setting of 0.016 inch (versus 0.010 inch). Time of fibrillation was 23 minutes. Visual examination was made and additional fibrillation added for 13 minutes. The temperature of the water rose to 82°F (27.78°C) [from 75°F (23.89°C)]. Again, a visual examination was made, followed by an additional 10 minutes fibrillation. Another examination was made, followed by additional fibrillation of 13 minutes. Final examination of fibers indicated a 60% fibrillation with approximately 20% broken fibers. The following classification was made for fiber length:

8 mesh: 94.4%; 14 mesh: 1.7%; 48 mesh: 1.7%; 100 mesh: 2.2%.

The drainage rate was 10.5 seconds.

Conclusion

The 0.016 gap setting does not offer an economical or quality advantage. The only result is an increased time span. The procesed fiber is usable as a test experiment and will be stored for a possible future felting experiment.

Experiment 5

Material Used

American Cyanamid Creslan, type 61, 5 denier, regular shrink, 3/4-inch length.

Operation A

The dry acrylic of 31 pounds from group 1 was added to the 5,000 pounds of water as established in experiment 4. The wetting time requirement remained 2 hours (per experiments 3 and 4). Visual examination of separation and wetness confirmed the acceptable condition.

Operation B

The wet fibers were transferred to the fibrillator holding tank and agitated per experiment 4.

Operation C

The fibrillation process was begun at a gap setting of 0.014 inch. Two passes through the fibrillator were made for a total fibrillation time of 1 hour, 3 minutes. The temperature rose to 82°F (27.78°C) from the 78°F (25.56°C) start. The resulting fiber appeared to be 70% fibrillated with the following fiber length classification:

8 mesh: 22.4%; 14 mesh: 21.2%; 48 mesh: 51.4%; 100 mesh: 5.0%.

The drainage rate was 11.0 seconds.

Conclusion

An improved fibrillation of fiber was achieved. The fibers were usable for a test experiment, but were still classified at only about 60% of normal acceptable quality.

Experiment 6

Material Used

American Cyanamid Creslan, type 61, 5 denier, regular shrink, 3/4-inch length.

Operation A

Dry fiber of 31 pounds net weight was added to the normal water amount (3,700 lb). The fiber was wetted to an acceptable stage by visual examination (1 hour, 10 minutes in water).

Operation B

The wet fibers were transferred to the fibrillator holding tank and agitated at the normal rate using the propeller and mixing blades.

Operation C

The fibrillation process started with a gap setting of 0.012 inch and one pass through the fibrillator. Total time of process was 50 minutes. Visual examination revealed a good fibrillation pattern of approximately 80% hits. The fiber length classification was as follows:

8 mesh: 1.2%; 14 mesh: 40%; 48 mesh: 56%; 100 mesh: 3%.

The drainage rate was 9.6 seconds.

Conclusion

Experiment 6 fiber as processed was the most usable of all fibers processed in experiments 1 through 6. It was decided to attempt a felting and molding process experiment utilizing those fibers from experiment 6.

Continuation of Experiment 6 — Felting and Molding Sequence

Material Used

American Cyanamid Creslan, type 61, 5 denier, regular shrink, 3/4-inch length. Processed by fibrillation as described in experiment 6.

With the acrylic fiber from fibrillation experiment 6, a normal formulation applicable to drawing 9247366 was prepared in the quantity of one-half size felting batch. (See Armtec Standard Practice Instruction M205-1 for formulation procedures.)

The felting methods were standard, using the same people and equipment used in every-day production of the M250 cartridge case. The normal adjustment to the equipment for wet felt weight standards was achieved. (See Armtec Manufacturing Standard Practice Instructions M205-3 for felting.) The body wet felt weight was 750 grams. The base weight was 175 grams wet. The body felts produced were 80 units. The base felts produced were 80 units.

The felts were then molded, by the same people and with the same equipment as are used in normal production of the cartridge cases. (See Armtec Manufacturing Standard Practice Insructions M205-4 and 5.)

The molded parts, off-die weights, were as follows:

Body -- average 336 grams

Base — average 73 grams

Inspection of parts after molding resulted in the following:

Body -- accepted 39; rejected 41 (35 for fiber separation and 5 for unacceptable weights).

Base -- accepted 70; rejected 10 (separations).

The acceptable parts were then trimmed, punched, and deflashed in accordance with Armtec Manufacturing Standard Practice Instructions for the M205 cartridge case.

The tensile test was performed for the body component of the cartridge case in accordance with Armtec Manufacturing Standard Practice Instructions M205-16 and MIL-C-50534 requirements with the following results:

Average: 2331 psi (high of 2350, low of 2310) with a density average of 0.794 (sample weight 295 grams).

This can be compared to the average readings of 3741 psi for production bodies manufactured the previous day (on a normal production batch, using specification

acrylic). It should be noted that the normal high readings of the production cases are in excess of the basic requirements of 2500 psi minimum (reference MIL-C-50534).

The tensile test for the base component of the cartridge case was similar and is shown as follows:

Composition	Specification requirements (%)	Experiment average (%)	Production average (%)
Nitrocellulose	55 ± 2.0	62.61	54.07
Diphenylamine	1 ± 0.3	0.80	0.89
Acrylic	25 ± 2.0	19.93	25.08
Kraft, resin and additives		16.66	19.96

The completed parts (30 bases, 30 bodies) were placed in storage awaiting instructions. One visual representative sample set was sent to the ARRADCOM Project Engineer.

Conclusions

Commercial fibers can be fibrillated. Additional tests should be conducted as follows:

1. Additional wetting agents or procedures should be explored.

2. Fibrillation-type machines of a common usage (such as Twin-Flo pressured refiners) should be investigated since the Armtec fibrillator is no longer being manufactured.

3. A tensile sample punch machine should be fabricated to reduce labor of preparing test samples. (It is estimated that perhaps 1,000 samples will be required for the completion of this contract.)

4. Test firings should be made as soon as possible to evaluate actual conditions of test samples (samples of Molding Test 1 are available).

5. A comparison burst test study should be made between Armtec production cases and the experimental cases using the experimentally fibrillated material (using TAPPI standards and equipment).

6. Batch formulation (note analysis of test cases) to conserve materials and labor. One-half batches are formulated (able to produce 10 cases and

bases) and standards for the use of the dry fibers of test acrylic and normal batch methods should be established.

No other recommendations were apparent at that point. Upon analysis of the data, it was recommended that a meeting be held to review the accomplishments, outline guidance for future experiments, and establish a schedule of requirements.

Experiment 7

Material Used

American Cyanamid Creslan, type X-61M, 5 denier, hi-shrink, 3/4-inch length.

Operation A

Dry fiber of 31 pounds net weight was added to 500 gallons of water. The fiber was mixed for dispersion for 15 minutes and allowed to "wet out" for 1 hour.

Operation B

The wetted acrylic fiber was transferred by pump to the fibrillation holding tank; the agitator and mixing blades were run at maximum speed (500 rpm) during the pumping transfer.

Operation C

The fibrillator was operated with a blade gap of 0.010 inch and a back pressure at 25 to 30 pounds. The blades utilized were a type 9 016A007. The starting temperature of the slurry was 78°F (25.56°C). The amperage of the pump motor was 40. Total fibrillation time was 24 minutes.

Operation D

The fibrillated fiber was drummed off and a sample was subjected to the following tests:

Drainage rate:	8.3 seconds
Freeness (Williams):	5.8 seconds

Classification: 8 mesh = 63.4%
14 mesh = 7.6%
48 mesh = 23.4%
100 mesh = 5.4%

Conclusion

Fibrillation poor when viewed under microscope; not usable for process.

Experiment 8

Material Used

du Pont Orlon, 5 denier, regular shrink, 3/4-inch length.

Operation A

Thirty-one pounds of net weight fiber were added to the standard 500 gallons of water and mixed to achieve dispersion. The slurry was allowed to continue the wetting sequence for 1 hour.

Operation B

The wetted fiber was transferred by pump to the fibrillation holding tank. The agitator and mixing blades of the holding tank were run at the maximum speed (500 rpm) to assure dispersion during the transfer.

Operation C

The fibrillator was operated with a blade gap of 0.008 inch (reduced from experiment 7) with the back pressure at 25 to 30 pounds. Prior to the start of fibrillation, the water temperature was 78°F (25.56°C). The initial pump motor amperage was 54 to 57; fibrillation time, 15 minutes.

Operation D

The fibrillated fiber was drummed off and a sample was subjected to the following tests:

Drainage rate:	1.1 seconds
Freeness (Williams):	6.2 seconds
Classification:	8 mesh = 78.9%
	14 mesh = 11.9%
	48 mesh = 10.0%
	100 mesh = 1.0%

Conclusion

Microscopic examination of the fibrillated fibers established that fibrillation was evident but the fibers were broken and unusable for felting or molding a quality product.

Experiment 9

Material Used

duPont Orlon, 5 denier, regular shrink, 3/4-inch length.

Operation A

Thirty-one pounds of net weight fiber were added to the standard 500 gallons of water and mixed to slurry dispersion. The mixture was allowed to continue the wetting sequence for 1 hour.

Operation B

The wetted fiber was transferred by pump to the fibrillation holding tank. The agitator and mixing blades of the holding tank were run at the maximum speed (500 rpm) to assure dispersion during the transfer.

Operation C

The fibrillator was operated with a blade setting gap of 0.008 inch. The back pressure was established at 40 to 45 pounds; the water temperature at the start of the fibrillation was 82°F (27.78°C); the initial pump motor amperage was 40 to 42. The fibrillation time was 8 minutes.

Operation D

The fibrillated fiber was drummed off and a sample subjected to the following tests:

Drainage rate:	3.4 seconds
Freeness (Williams):	5.8 seconds
Classification:	8 mesh = 54.4%
	14 mesh = 21.9%
	48 mesh = 20.3 %
	100 mesh = 3.2%

Conclusion

Microscopic examination of the fibers showed an improved fibrillation of the fibers with some breakage. Although the sample was not of a quality usable in existing production standards, it was decided to utilize the material for a felting and molding attempt.

Continuation of Experiment 9 -- Felting and Molding Sequence

Material Used

duPont Orlon, 5 denier, regular shrink, 3/4-inch length.

With the processed fiber from experiment 9, a normal production formulation was prepared reflecting the production methods applicable to the manufacture of 152-mm cartridge case M205.

The felting method employed was standard, utilizing the identical equipment of the M205 cartridge case.

The molding tooling was identical to the production of the M205 cartridge case.

Felting Conclusion

Results were uniformly poor. The felting time required to produce a wet felt of the theoretical, required weight for an in-tolerance dry felt was 20 to 25% higher (even though consistency as measured was at the 0.17 range). Wet felts were mushy, and stuck to the felting die.

Molding Conclusion

Upon molding, all parts showed bad delaminations throughout. The batch was scrapped after 10 samples were produced for visual examination.

General Conclusion

The finished product cartridge cases were not usable; the quality was poor and was caused by the acrylic fiber processing. Ten units were preserved for future reference.

Experiment 10

Material Used

duPont Orlon, denier 5, regular shrink, 3/4-inch length.

Operation A

Thirty-one pounds of net weight fiber were added to 500 gallons of water and mixed to achieve proper dispersion; the slurry was then allowed to "wet out" for 1 hour.

Operation B

The water/fiber mixture was then transferred to the fibrillation holding tank; the agitator and mixing blades of the holding tank were at 500 rpm to assure dispersion during the transfer.

Operation C

The fibrillator was operated with a blade setting gap of 0.008 inch; the back pressure was established at 25 to 30 pounds; the water temperature at the start of fibrillation was 74°F (23.33°C); and the initial pump motor amperage was 41 to 42. The fibrillation time was 5 minutes.

Operation D

The fibrillated fiber was drummed off and a sample subjected to the following tests:

Drainage rate:	1.3 seconds
Freeness (Williams):	3.9 seconds
Classification:	8 mesh = 71.9%
	14 mesh = 13.4%
	48 mesh = 13.7%
	100 mesh = 0.9%

Conclusion

Microscopic examination showed fair fibrillation with few fines. Since a good portion of the strands were untouched by the fibrillator, it was decided to run the material through again with a slight increase in back pressue in the attempt to more thoroughly fibrillate the longer fibers. The material was refibrillated in accordance with operation C.

The refibrillated fiber was drummed off and a sample subjected to the following tests:

Drainage rate:	2.3 seconds
Freeness (Williams):	5.5 seconds
Classification:	8 mesh = 54.4%
	14 mesh = 22.8%
	48 mesh = 21.2%
	100 mesh = 1.4%

Microscopic examination of the material showed fair fibrillation, probably usable in the system. Material was stored for future use.

Experiment 11

Material Used

duPont Orlon, 5 denier, regular shrink, 3/4-inch length.

Operation A

Thirty-one pounds of net weight fiber were added to 500 gallons of water and mixed to achieve a proper dispersion of the fibers in the water. This slurry was then allowed to "wet out" for a total "fiber-in-water" time of 1 hour.

Operation B

The mixture of fiber and water was then transferred to the fibrillation holding tank; agitation was introduced to the mixture by the use of propeller-type blades turning at 500 rpm. This agitation accorded a thorough mixture of water and fiber during the pumping transfer.

Operation C

The fibrillating equipment was operated at a minimum gap setting (0.006 in.). This minimum setting of the gap is considered a risk to the fibrillator to the possible damage of the cutting blades. Temperature of water at start was 76°F (24.44°C); amperage, 67 to 70; back pressure, 25 to 30 pounds; fibrillation time, 15 minutes.

Operation D

The fibrillated fiber was transferred to storage drums and a sample of the fiber was tested, with the following results:

Drainage rate:	1.8 seconds
Freeness (Williams):	6.5 seconds
Classification:	8 mesh = 29.4%
	14 mesh = 12.2%
	48 mesh = 45.8%
	100 mesh = 12.4%

Conclusion

Microscopic examination of the material revealed good fibrillation throughout but with an excess of fines. The material was stored for possible future use or reference.

Experiment 12

Material Used

Monsanto Acrilan, 5 denier, regular shrink, 3/4-inch length.

Operation A

The Monsanto fiber (31 lb) was added to 500 gallons of water and mixed to proper dispersion; the standard 1 hour "wet out" period of time was observed.

Operation B

The mixture of the Monsanto fiber was transferred to the fibrillation holding tank. Agitation was introduced to the slurry by the use of propeller-type blades turning at 500 rpm during the pumping transfer to assure a thorough mixture.

Operation C

The fibrillating equipment was operated at a minimal gap setting (0.006). The water temperature at the start was 78°F (25.56°C). The amperage was 60 to 64; the back pressure was 20 to 25 pounds; and the fibrillation time was 15 minutes.

Operation D

The fibrillated fiber was transferred to storage drums and a sample of the fiber was tested, with the following results:

Drainage rate:	2.4 seconds
Freeness (Williams):	7.6 seconds
Classification:	8 mesh = 23.1%
	14 mesh = 13.5%
	48 mesh = 49.1%
	100 mesh = 14.1%

Conclusion

Microscopic examination of this material showed very good fibrillation. Start and finish fibrillation results are indicative of a good initial fibrillation with material flowing freely through the equipment. Material was stored for future use.

Experiment 13

Material Used

Monsanto Acrilan, 5 denier, regular shrink, 3/4-inch density.

Operation A

Due to the improved results of fibrillation in experiment 12, it was decided to process a full (66 lb) batch of the same material. The 66 pounds of net weight fiber was added to 1000 gallons of water and mixed to proper dispersions. A 1-hour "wet out" time was observed.

Operation B

The slurry of water and Monsanto fiber was then transferred to the fibrillation holding tank. The agitator and mixing blades of the holding tank were operated at a speed of 500 rpm to assure proper dispersion during the pumping transfer.

Operation C

The fibrillator was operated with the minimum blade setting (0.006 in.). The back pressure was maintained at 20 to 25 pounds. The water temperature at the start of fibrillation was 74°F (23.33°C); the initial pump motor amperage was 60 to 61; the fibrillation time was 20 minutes.

Operation D

The fibrillated fiber was drummed off and a sample subjected to the following tests:

Drainage rate:	2.7 seconds
Freeness (Williams):	7.2 seconds
Classification:	8 mesh = 15.5%
	14 mesh = 13.7%
	48 mesh = 54.2%
	100 mesh = 16.4%

Conclusion

Microscopic examination of the fibrillation showed approximately the same as experiment 12. The fibrillation was good; however, the close setting of the blades produces many fines and increases the wear on the fibrillation blades. The material was stored for future reference or use.

Experiment 14

Material Used

American Cyanamid, type X-99, 5 denier, regular shrink, 3/4-inch length.

Operation A

The American Cyanamid fiber (31 lb) was added to 650 gallons of water and was "wet out" under agitation for 1 hour as had been done in previous experiments.

Operation B

The slurry of fiber and water was transferred to the fibrillation holding tank. Proper agitation with the mixing blades at 500 rpm assured a thorough mixing during the transfer.

Operation C

The fibrillator was operated with the minimum blade gap of 0.006 inch; the back pressure was maintained at 35 pounds; the water temperature at the start of fibrillation was 76°F (24.44°C). The initial pump motor amperage was 61 to 64. The total fibrillation time expended was 15 minutes.

Operation D

The fibrillated fiber was drummed off and a sample subjected to the following tests:

Drainage rate:	2.5 seconds
Freeness (Williams):	7.6 seconds
Classification:	8 mesh = 14.8%
	14 mesh = 10.3%
	48 mesh = 58.3%
	100 mesh = 16.4%

Conclusion

Microscopic examination confirmed very good fibrillation of the fiber. The excess presence of fines, however, presented a quality control problem applicable to manufacture of acceptable cartridge cases.

Experiment 15

Material Used

duPont Orlon, 5 denier, regular shrink, 3/4-inch length.

Operation A

Thirty-one pounds of net weight fiber were added to 500 gallons of water and mixed to achieve proper dispersion. The slurry was allowed to "wet out" for 1 hour.

Operation B

The water/fiber slurry was then transferred to the fibrillation holding tank. The agitator and mixing blades of the holding tank were operated at 500 rpm to assure dispersion of the fibers during the transfer.

Operation C

The fibrillator was operated with a blade setting gap of 0.006 inch. The back pressure was adjusted to 20 to 25 pounds; the water temperature at the

start of fibrillation was 74°F (23.33°C). The initial pump motor amperage was 60 to 62. The fibrillation time was 20 minutes.

Experiment Aborted

Mechanical failure of a pump contaminated the fiber material during the transfer of fiber to storage drums.

Conclusion

No tests performed due to the contamination of fibers.

Experiment 16

Material Used

American Cyanamid, type 2B5025, 5 denier, regular shrink, 3/4-inch length.

Operation A

The 31 pounds of acrylic fiber were added to 500 gallons of water and mixed to the desired dispersion of all the fibers. To assure proper "wet out", the fibers were agitated in the mixture for a total time of 1 hour.

Operation B

The fiber and water slurry was then pumped into the fibrillation holding tank. The mixing blades of the holding tank were operated at a constant speed of 500 rpm to assure proper dispersion of the fibers in the water during the transfer.

Operation C

The fibrillator was then operated with the blade setting of 0.006 inch. The back pressure was reduced to a minimum of 14 to 17 pounds in an effort to reduce the fines in the process. The length of the f ··illation time was also reduced to 10 minutes.

Preliminary examination by microscope revealed minimum fibrillation, with many fibers smooth and untouched by the operation. It was decided to rerun the material through the fibrillator a second time to achieve additional fibrillation.

The machine was reset to a gap setting of 0.006 inch; the back pressure was maintained at 16 to 18 pounds; the amperage was 50 to 52; fibrillation time was 10 minutes.

Operation D

The processed fiber was drummed off and a sample was tested, with the following results:

Drainage rate:	5.1 seconds
Freeness (Williams):	4.8 seconds
Classification:	8 mesh = 45.5%
	14 mesh = 21.8%
	48 mesh = 30.2%
	100 mesh = 3.1%

Conclusion

Microscopic examination of the rerun fibers showed a generally improved fibrillation. However, a large proportion (approximately 30%) of broken fiber shafts were apparent. It was decided to utilize the fibers in a felting/molding attempt.

Continuation of Experiment 16 — Felting and Molding Sequence

Material Used

American Cyanamid, type 2B5025, 5 denier, regular shrink, 3/4-inch length. This fiber was the result of the fibrillation experiment 16.

With the processed fibers, a normal production formulation was prepared. The methods of the felting and molding sequence were identical to the production standards of the manufacture of the 152-mm M205 combustible cartridge case. Identical equipment and tools were utilized.

Conclusions

Felting. The material felted on the forms was difficult to remove from the felting screens. The material remained wet and uneven. The product was not acceptable.

Molding. The molding attempts were not consistent and evidenced extreme vertical delamination. The effort to produce usable parts was excesive. Ten units were retained for future reference; all other parts were destroyed.

Experiment 17

Material Used

American Cyanamid, type 2B5025, 5 denier, standard shrink, 3/4-inch cut length.

Operation A

The dry fiber (31 lb) was added to the standard 500 gallons of water. The fiber was mixed for dispersion. The slurry was then allowed to "wet out" for 1 hour.

Operation B

The water and fiber slurry was then transferred to the fibrillation holding tank. The agitator and mixing blades of the holding tank were operated at 500 rpm to assure dispersion during the transfer.

Operation C

The fibrillator was operated at an increased gap setting (0.012 inch versus 0.006 inch) in an attempt to reduce the quantity of broken fibers experienced in the previous experiments.

The back pressure was maintained at 20 to 25 pounds; the water temperature at the start was 76°F (24.44°C); the pump motor amperage was 60 to 64; and the fibrillation time was 10 minutes.

Operation D

The fibrillated fiber was drummed off and a sample was subjected to the following tests:

Drainage rate:	5.3 seconds
Freeness (Williams):	9.8 seconds
Classification:	8 mesh = 26.5%
	14 mesh = 15.5%
	48 mesh = 46.1%
	100 mesh = 11.7%

Conclusion

Microscopic examination of the fiber showed an improved fibrillation, judged to be 65%, of an acceptable quality. It was decided to attempt a felting/molding operation to judge the fibers in a finished condition.

Continuation of Experiment 17 — Felting and Molding Sequence

Material Used

American Cyanamid, type 2B5025, 5 denier, standard shrink, 3/4-inch cut length. The fiber was the result of the fibrillation experiment 17.

With the processed fibers, a normal production batch was formulated. The consistency of 0.18% was established.

Conclusions

Felting. The felted forms were wet and bulky. The felted form was difficult to remove from the felting tool. The pre-dry was increased to reduce the water content of the wet felt without improving the felt. The forms, as felted, were of poor quality and not considered acceptable due to the length of felting time and difficulty of removal from the forms.

Molding. The felts molded reasonably well, but the usual vertical delaminations were evidenced on blow-off, with some parts blowing apart at the bottom (bodies). Bases molded fairly well, but they too were soft and evidenced delamination on the inside of the base. Thirty-six body units were retained for observation. The batch was then "felted out" and destroyed by burning.

Experiment 18

Material Used

American Cyanamid, type 2B5025, 5 denier, standard shrink, 3/4-inch cut length.

Operation A

The dry fiber (31 lb) was mixed into 500 gallons of water in accordance with previous experiments. After the fiber was dispersed equally in the water, the slurry was allowed to "wet out" for 1 hour.

Operation B

The fiber-and-water slurry was then transferred to the fibrillation holding tank. Mixing blades of the agitator were operated at the established 500 rpm to assure continued dispersion during the transfer operation.

Operation C

The fibrillator gap setting was again 0.012 inch. The back pressure was reduced to 15 to 20 pounds in an attempt to reduce fiber breakage as had occurred in experiment 17. The water temperature at the start was 73°F (22.78°C); the pump motor amperage was 54 to 57; fibrillation time was 15 minutes.

Operation D

The process fiber was drummed-off and a sample was tested as follows:

Drainage rate:	4.1 seconds
Freeness (Williams):	3.6 seconds
Classification:	8 mesh = 51.1%
	14 mesh = 14.4%
	48 mesh = 28.5%
	100 mesh = 5.9%

Conclusion

Microscopic examination of the processed fiber showed relatively poor fibrillation ("unhit" fibers) when compared to previous experiments. A sample of the material was again introduced into a water mixture (1 lb wet fiber to 15 gal. water) and mixed by hand for 15 minutes. It was then observed that many floating fibers were present (estimated at 5 to 8% of total fibers). Examination of these fibers indicated a lack of "wetness." The dry fibers refused to absorb water.

It was decided to repeat the fibrillating cycle (Operation C) in an attempt to produce usable fiber.

Operation A Repeat

The "drummed" fiber was reintroduced into a water bath and allowed to disperse under agitation (400 gal.) of water added to the wet fibers). After 1 hour, it was observed that floating fibers (approximately 5%) were still present.

Operation B Repeat

The fiber-and-water slurry was transferred to the fibrillation holding tank. The mixing blades were operated at the standard 500 rpm to assure dispersion during the transfer.

Operation C Repeat

The fibrillator gap setting was again set at 0.012 inch and the processed material was reprocessed for an additional 15 minutes.

Operation D Repeat

The reprocessed material was then rerun through the classificatin test, resulting in the following:

9 mesh = 36.1%
14 mesh = 17.0%
48 mesh = 39.3%
100 mesh = 7.4%

Conclusion

Microscopic examination revealed very little improvement when compared to the initial experiment. Floating fibers were still evident and poor fibrillation dictated that the fiber was unusable and probably contaminated. It was decided to "drum off" the material and destroy it.

Experiment 19

Material Used

American Cyanamid, type 2B5024, 5 denier, standard shrink, 3/4-inch cut length.

Operation A

A mixture of 31 pounds dry fiber and 500 gallons of water was prepared. The fiber was allowed to disperse and "wet out" for 1 hour.

Operation B

The slurry of dispersed fiber and water was then transferred to the fibrillation holding tank. Mixing equipment was activated to insure adequate fiber dispersion during the transfer operation.

Operation C

The fibrillation equipment was prepared for use and the initial gap setting was reduced to 0.010 inch. The back pressure was maintained at a minimum 15 pounds. The water temperature at the start was 75°F (23.89°C). The pump motor amperage was 50 to 60. Fibrillation time was 10 minutes.

Examination

The processed fiber was examined in the tank with all mixing blades out of operation. The floating fibers of experiment 18 were not evident. A 1% no-rise was present, not the 6 to 8% previously experienced.

Microscopic examination revealed insufficient fibrillation, with approximately 25% of the fibers being unmarred.

A second fibrillation attempt of 10 minutes was decided upon.

Fibrillation Second Attempt

The second run showed better overall fibrillation but still insufficient for the felting attempt. It was decided to reprocess the fiber in a third attempt.

Fibrillation Third Attempt

Microscopic examination revealed good fibrillation throughout the fibers. The quantity of fibrillated long fibers was superior to other experiments of the same material.

Operation D

The processed fiber was "drummed off" and the following tests performed:

Drainage rate:	4.1 seconds
Freeness (Williams):	8.0 seconds
Classification:	8 mesh = 52.3%
	14 mesh = 13.8%
	48 mesh = 28.9%
	100 mesh = 4.9%

Conclusion

Microscopic examination of the fibrillation indicated a superior product that should be utilized for a felting/molding experiment.

Continuation of Experiment 19 — Felting and Molding Sequence

Material Used

American Cyanamid, type 2B5025, 5 denier, standard shrink, 3/4-inch cut length. The fibrillated fiber was the result of the fibrillation experiment 19.

Conclusions

Felting. Utilizing the processed fibers, a normal production batch was formulated to a 0.20% consistency and then reduced by dilution to 0.17% consistency. The felted parts were easily removed from the felting forms with very little indication of sticking or undue bulkiness. Felting times were in the normal range (2 to 3 min.) but required frequent adjustments to maintain molding weight.

Molding. This was successful, with the exception of minor separations on the sides of the cartridge case. Thirty-nine units were accepted.

Experiment 20

Material Used

American Cyanamid, type 2B5025, 1.5 denier, standard shrink, 3/4-inch cut length.

Operation A

The acrylic fiber (1.5 denier) was added to 500 gallons of water. The standard weight of 31 pounds dry weight was maintained even though the fiber was of a thinner diameter. The fiber was allowed to disperse and to "wet out" for a total of 1 hour.

Operation B

The slurry of fiber and water was transferred to the fibrillation holding tank. The mixing blades were then activated at 500 rpm to insure dispersion of the fibers during the transfer operation.

Operation C

The fibrillation equipment was prepared for use, utilizing a gap setting of 0.006 inch (to correspond with the reduced diameter of the fiber).

The back pressure was maintained at 15 pounds. The water temperature was 77°F (25°C). The pump motor amperage was 67 to 70. Fibrillation time was 10 minutes.

Operation D

The fibrillated fiber was "drummed off" and the following tests performed:

Drainage rate:	5.7 seconds
Freeness (Williams):	6.6 seconds
Classification:	8 mesh = 14.8%
	14 mesh = 36.1%
	48 mesh = 37.4%
	100 mesh = 11.5%

Conclusion

Microscopic examination indicated good fibrillation on the thinner fiber; however, a quantity of "knots" (approximately 3%) caused some concern for fusion or melting together of fibers. Subsequent dissection of the "knots" revealed no fusion of the fibers, but merely a tangle of fibers still independent of each other.

It was decided to proceed with a felting/molding experiment utilizing the processed fibers of this experiment.

Continuation of Experiment 20 — Felting and Molding Sequence

Material Used

American Cyanamid, type 2B5024, 1.5 denier, standard shrink, 3/4-inch cut length. This fibrillated fiber was the result of the fibrillation experiment 20.

Conclusions

Felting. The processed fibers were utilized to prepare a simulated product batch for the 152-mm combustible cartridge case M205 using the existing equipment and process. The batch was formulated to a 0.15% consistency. The preform felts were quickly formed within the normal production felting time (2 to 3 min.) and reached the acceptable wet weight tolerance. The felts were easily removed, leaving a clean felting die. It was observed that the felting process did create definite spots of different thickness, perhaps caused by the "knots" previously described in the conclusion discussion of the fibrillation effort.

Molding. The felted preforms molded with some soft spots with minor separations. The quality, however, was considered good, and forty units were accepted.

Experiment 21

Material Used

American Cyanamid, type 2B1525, 1.5 denier, standard shrink, 3/4-inch cut length.

Operation A

The acrylic fiber (31 lb dry weight) of the thin diameter (1.5 denier) was added to 500 gallons of water. The mixture was agitated to insure dispersion and allowed to "wet out" for 1 hour.

Operation B

The water/fiber slurry was then transferred to the holding tank. The agitation blades were run at the standard 500 rpm to insure dispersion of the fibers in water during the transfer operation.

Operation C

The fibrillator was prepared for operation by adjusting the blade gap to 0.010 inch (was 0.006 inch), an increase of gap made in an effort to reduce the maceration of fibers during the process.

The back pressure of the pump was maintained at 15 pounds. The water temperature was 74°F (23.33°C) at the start of the fibrillation process. The pump motor amperage was 61 to 67; fibrillation time was 10 minutes.

Operation D

The fibrillated fibers were "drummed off" and tested as follows:

Drainage rate:	1.8 seconds
Freeness (Williams):	5.9 seconds

Classification:	8 mesh = 64.0%
	14 mesh = 9.1%
	48 mesh = 21.6%
	100 mesh = 5.1%

Conclusion

Microscopic examination showed less breakage of the fibers but, unfortunately, approximately 12% untouched fibers.

It was decided to attempt a felting/molding experiment utilizing the fibers as processed in this experiment (21).

Continuation of Experiment 21 -- Felting and Molding Sequence

Material Used

American Cyanamid, type 2B152J, 1.5 denier, standard shrink, 3/4-inch cut length, fibrillated by the process of experiment 21.

Conclusions

Felting. The processed fibers were prepared using a standard process (152-mm cartridge case M205) utilizing the existing production equipment and methods. The batch was formulated to a 0.17% consistency. A few parts were felted, but resulted in the material's sticking to the felter form. The consistency was reduced to 0.13% by adding water to the formulation. The sticking persisted and only 25 units were judged acceptable for a molding attempt.

Molding. The preforms were molded with extreme care and handling. Unfortunately, the resulting product showed vertical cracking at the removal sequence. Exterior examination showed the molded parts to be fuzzy with a fine dust resulting from rubbing of the hand against the molded surface. This condition, resulting from incomplete resin binding of the fibers during molding, is not acceptable. Eighteen units were retained for study.

Experiment 22

Material Used

American Cyanamid, type X99, 5 denier, standard shrink, 3/4-inch cut length.

Operation A

The acrylic fiber of 5 denier weighing 31 pounds dry weight was added to the standard 500 gallons of water. (The 1.5 denier of experiments 20 and 21 was not repeated.) The slurry was agitated and allowed to "wet out" for 1 hour.

Operation B

The slurry of fiber and water was then transferred to the fibrillation holding tank and agitated during the transfer to insure proper dispersion of the fibers.

Operation C

A blade gap of 0.006 inch was used for the fibrillation process. The back pressure of the pump was 20 pounds. The water temperature at the start was 74°F (23.33°C); the pump motor amperage was 59 to 61; and fibrillation time was increased to 15 minutes.

Operation D

The fibrillated fiber was "drummed off" and tested as follows:

Drainage rate:	2.6 seconds
Freeness (Williams):	7.8 seconds
Classification:	8 mesh = 13.6%
	14 mesh = 23.0%
	48 mesh = 54.2%
	100 mesh = 9.2%

Conclusion

Microscopic examination indicated fibrillation of a minimum acceptability, with 95% of the fibers modified to some extent. Fiber breakage (20%) was also evident. It was decided to attempt a felting/molding experiment using the material of this experiment.

Continuation of Experiment 22 -- Felting and Molding Sequence

Material Used

American Cyanamid, type X99, 5 denier, standard shrink, 3/4-inch cut length, fibrillated by experiment 22.

Conclusions

Felting. The fibers fibrillated in experiment 22 were prepared for the Felting experiment by the formulation process utilized in the production of the 152-mm M205 cartridge case. The consistency was maintained at 0.16%. The actual felting sequence again experienced sticking of the fibers to the felting form. All usable felts required extensive care and handling.

Molding. When molded, the preforms produced parts of an acceptable quality but with surface roughness. Long exposed fibers that can be described as "hairy" soft spots were apparent in approximately 50% of the units. Forty units were accepted at the minimum quality level.

Experiment 23

Material Used

American Cyanamid, type X99, 5 denier, standard shrink, 3/4-inch cut length.

Operation A

The standard 31 pounds of acrylic fiber were added to 500 gallons of water and mixed by agitation and allowed to "wet out" for 1 hour.

Operation B

The water/fiber slurry was then transferred to the fibrillation holding tank and agitated during the transfer to insure proper dispersion of the fibers in the water.

Operation C

The fibrillation process was performed utilizing a blade gap setting of 0.010 inch. The back pressure of the pump was 15 to 20 pounds; the water temperature at the start was 75°F (23.89°C); the pump motor amperage was 57 to 60; and fibrillation time was 10 minutes.

Operation D

The fibrillated fiber was "drummed off" and tested as follows:

Drainage rate:	5.4 seconds
Freeness (Williams):	7.0 seconds
Classification:	8 mesh = 14.2%
	14 mesh = 28.2%
	48 mesh = 50.4%
	100 mesh = 7.2%

Conclusion

Microscopic examination showed fair fibrillation, with the majority of strands altered to some extent. However, strand breakage was evident (approximately 15%).

It was decided to attempt a felting/molding experiment using the material of this experiment.

Continuation of Experiment 23 — Felting and Molding Sequence

Material Used

American Cyanamid, type X99, 5 denier, standard shrink, 3/4-inch cut length, fibrillated by experiment 23.

Conclusions

Felting. The material was "batched" in accordance with the standard procedure for manufacture of the M205 cartridge case production. A consistency of 0.15% was established. The actual felting sequence resulted in felts' sticking to the form. Additional problems of bulk on the form and weight control resulted in a high reject rate of a product of poor quality.

Molding. The molding sequence was performed in accordance with the standard procedure for the M205 cartridge case.

The resulting product exhibited vertical cracks and folds, and in many cases, actual breakage upon removal from the molding dies.

The reject rate was high (approximately 70%); however, eighteen units were accepted for record.

General Conclusion of Experiments 1 through 23

The various commercial acrylic fibers in this series of experiments (1 through 23), although all being fibrillatable, were not at that state of the art, capable of being utilized in production of acceptable products.

Background

All experimental samples of commercial acrylic fiber failed to "wet out" as production material does, although visually adequate fibrillation seemed to be attained. Addition of "wetting agents" to all batches made little or no difference. The slurry in the felting tank showed stratification of material (finer material towards the bottom of the tank graduating to longer material which tended to float) even under high agitation.

Analysis of this phenomenon indicated that finer fibers accumulated on the felting screen first, with the longer fibers assuming a matrix over the shorter fibers prior to the end of the felting cycle. This is evidenced by bulky, wet felts (dead head of finer fibers on the screen preventing the water accumulated by longer fibers from being evacuated).

When this type of felt is formed, wet felts stick to the screen and molded parts crack on blow-off from the molds because of unequal distribution of various fibers and, therefore, unequal moisture distribution in the felt cross section.

The commercial fibers, even though fibrillated, appeared as monofilament, whereas the production fiber showed swelling and definite striation of the strands. It is presumed that this phenomenon resulted from the excellent wetting effect on thses fibers, with resultant homogeneity of the slurry and, therefore, better felts--thus better molded parts.

Pre-Swelling Approach

In a review by Armtec and ARRACOM personnel of results obtained, it was suggested that an attempt be made to "pre-swell" the commercial acrylic fiber to bring it into a "gel state" similar to that of a production material (Creslan T-98).

Microscopic examination showed significant swelling of a small sample of 5 denier, regular shrink American Cyanamid fiber immersed in a 50% aqueous ammonium thiocyanate solution for 2 hours. Further swelling did not occur with longer immersion. The ARRADCOM Project Officer suggested the use of a 40% sodium thiocyanate aqueous solution. This material was procured and used in subsequent batches as described below.

Additionally, since batches 20 and 22 showed signs of approaching production quality, it was recommended that further formulating work be conducted on these two acrylic materials in an attempt to strengthen the finished product in each case and to achieve in-tolerance chemical analysis.

Experiment 24

A cursory R&D program was instituted to determine the relative benefits of using sodium thiocyanate[2] as a wetting swelling agent for commercial acrylic fiber to provide a fibrillatable acrylic from a commercial source for a specialized felted/molded product (M205 combustible cartridge case).

The material selected for tests was American Cyanamid, type 2B1525, 1.5 denier, regular shrink.

Background

Initially a small amount of the acrylic material was treated in the laboratory in a 40% solution for indications of swelling. Definite swelling was noted within 15 minutes at room temperature (70°F), with no further swelling observed in 1 hour.

Production Attempt

A one-half batch of the standard felting formula was prepared utilizing a "swelled" acrylic.

An unsuccessful initial attempt was made to wet out the acrylic in two 30-gallon drums with "solution."

The decision was then made to transfer the acrylic to the fibrillation (agitation) tank with approximately 150 gallons additional water added to the solution.

---

[2] Crystals, technical grade, Witco Chemical, Brooklyn, N. Y. 11231.

The material was microscopically checked at 10-minute intervals for evidence of fiber swelling again. The first sample seemed indicative of maximum swelling effect of the solution on the fiber.

The material was then transferred to a holding tank in which the solution was thoroughly washed out with clean water (chemical analysis corroborates this).

The material was returned to the fibrillation tank and fibrillated in 500 gallons of water as follows:

	Set	Time	Results
First Run:	0.006	5 min.	(figure 20)
Second Run:	0.004	10 min.	(figure 21)

As noted, the processing of the fiber in the fibrillator was followed microphotographically.

On conclusion of fibrillation, the acrylic material was added to a production half-batch, per normal methods, and the batch was allowed to agitate overnight.

The next morning both bodies and bases were felted and molded from this batch.

The first parts processed showed some slight delamination on body exteriors and considerable delamination on base boss interiors. Slurry consistency was cut to approximately 0.12% with excellent results.

The resulting bodies and bases were smooth, unmarked, and in general, of good workmanship. The product (40 units) was finished per normal production, gauged, and packed for disposition by the ARRADCOM Project Engineer.

Normal Chemical Test, Stability Test, and Tensile Test were performed on AQL samples as available. Results were within the envelope tolerance with the exception of the nitrocellulose content of the batch, which was slightly high. (Adjustments can be made to compensate for this formulation--a normal sequence with the addition of new materials.)

Conclusion

It was the opinion of the ARRADCOM Project Officer that the results of experiment 24 were successful and in fact completed the objective of the scope of work of the contract.

CONCLUSIONS

The use of solvent-type swelling agents such as the 40% aqueous sodium thiocyanate solution produced sufficient fiber swelling to permit satisfactory fibrillation of a commercially produced Creslan acrylic fiber.

This new fibrillated fiber may be used in the production of combustible cartridge cases.

RECOMMENDATION

Additional work should be undertaken to develop production methods for the fibrillation of different types of commercial acrylic fiber.

It is the opinion of the ARRADCOM Project Engineer that commercial acrylic fibers other than Creslan could be made fibrillatable by swelling them in an appropriate solvent. Solvents such as those used in the spinning of various types of commercial acrylic fibers may be used as swelling agents for their specific fibers.

APPENDIX A

COMBUSTIBLE CARTRIDGE CASE MANUFACTURE

Description

The current state-of-the-art for the molding of high-density, combustible ordnance items evolved from the various slurry preform and pressing techniques that have been employed during the past century in the manufacture of three-dimensional shapes from wood cellulose fibers (fig. A-1). Basically, it is a commercial art for making hollow wares of a paperboard-type composition.

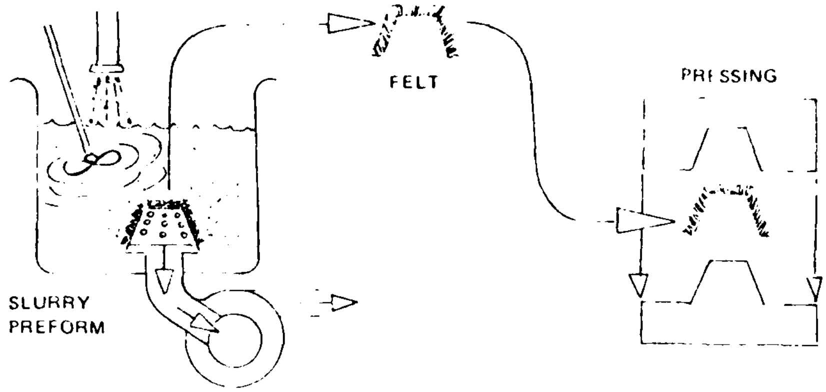


Figure A-1. Basic felting/molding process

The present method employed by Armtec in making high-density, combustible ordnance items is described in the following sections. The method described was employed to manufacture the test cartridge cases utilizing the fibrillated acrylic fiber applicable to this report.

Batch Preparation

1. The acrylic fiber, Creslan T-98, is fibrillated through the deflaker prior to its use in batch preparation (fig. A-2). The fibrillation is completed when the drainage rate of 15 to 18 seconds is met in accordance with TAAPI Standard T-1002 SO-6.

2. A hydropulper is filled with a predetermined amount of water.

3. The specified amount of fibrillated acrylic fibers is added to the hydropulper.

4. The mixture is beaten until all the fibers are well dispersed.

5. The contents are then pumped to a mixing tank.

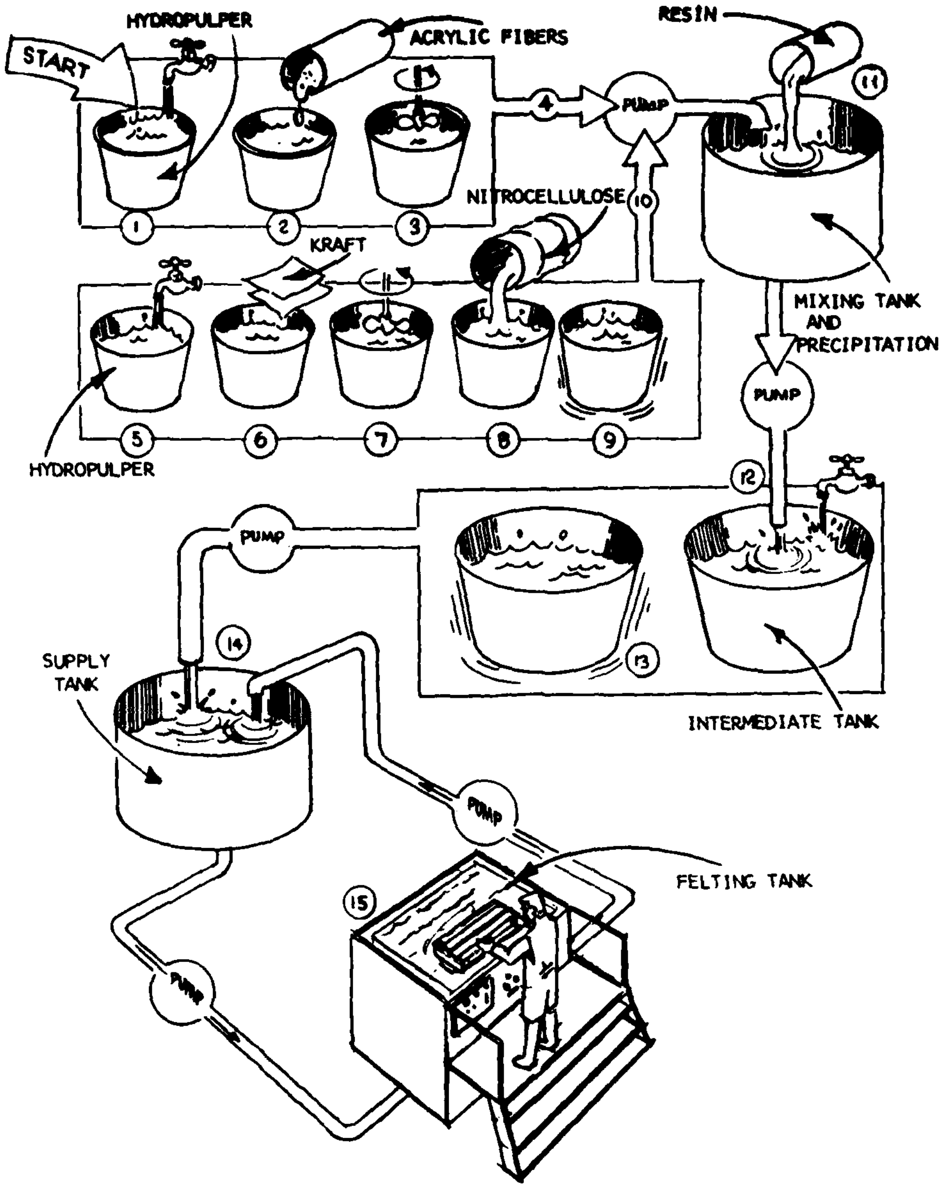


Figure A-2. Batch preparation

6. The hydropulper is again filled with the proper amount of water.

7. A specific amount of Kraft fibers is added to the water.

8. The mixture is beaten until the fibers are well dispersed.

9. A measured amount of nitrocellulose fibers is then added.

10. The entire batch is agitated for a few seconds until a homogeneous mix is obtained.

11. The homogeneous mixture is added to the mixing tank.

12. Resin is added within the mixing tank by employing the various prescribed steps that will obtain complete precipitation of the resin upon the fibers.

13. The batch is then pumped to a large intermediate tank, and sufficient water is added to reduce the slurry consistency to approximately 0.15% solids.

14. The batch is then allowed to stand under constant agitation for a minimum of 1 hour.

15. The slurry mix or batch is then pumped to a final supply tank where the mixture is kept in suspension by constant agitation.

16. The slurry is pumped from the supply tank to the felting tank on a continuous basis, through the bottom of the felting tank. The felting tank is then allowed to overflow evenly on all four sides. This overflow is returned to the supply tank, on a continuous basis. The slurry mixture is kept in constant agitation by mechanical methods.

Felting

Preforms are made in the felting tank by vacuum accretion of the fibers onto a perforated and screened shape (felting die) having exterior dimensions comparable to the interior configuration of the finished part. The perforated shape is affixed to a manifold, which is connected to a vacuum source.

The felting shape is immersed mechanically into the felting tank, and vacuum is applied. The length of immersion time plus the extent of vacuum dictates the amount of buildup of fibers around the exterior wall of the preform shape. This, in turn, controls the weight of the preform (fig. A-3).

When the preform, or "felt," is removed from the felting shape, it is a soggy, loosely bonded matrix (approximately 60% water) with a wall thickness 3 1/2 times greater than the finished part to be molded.

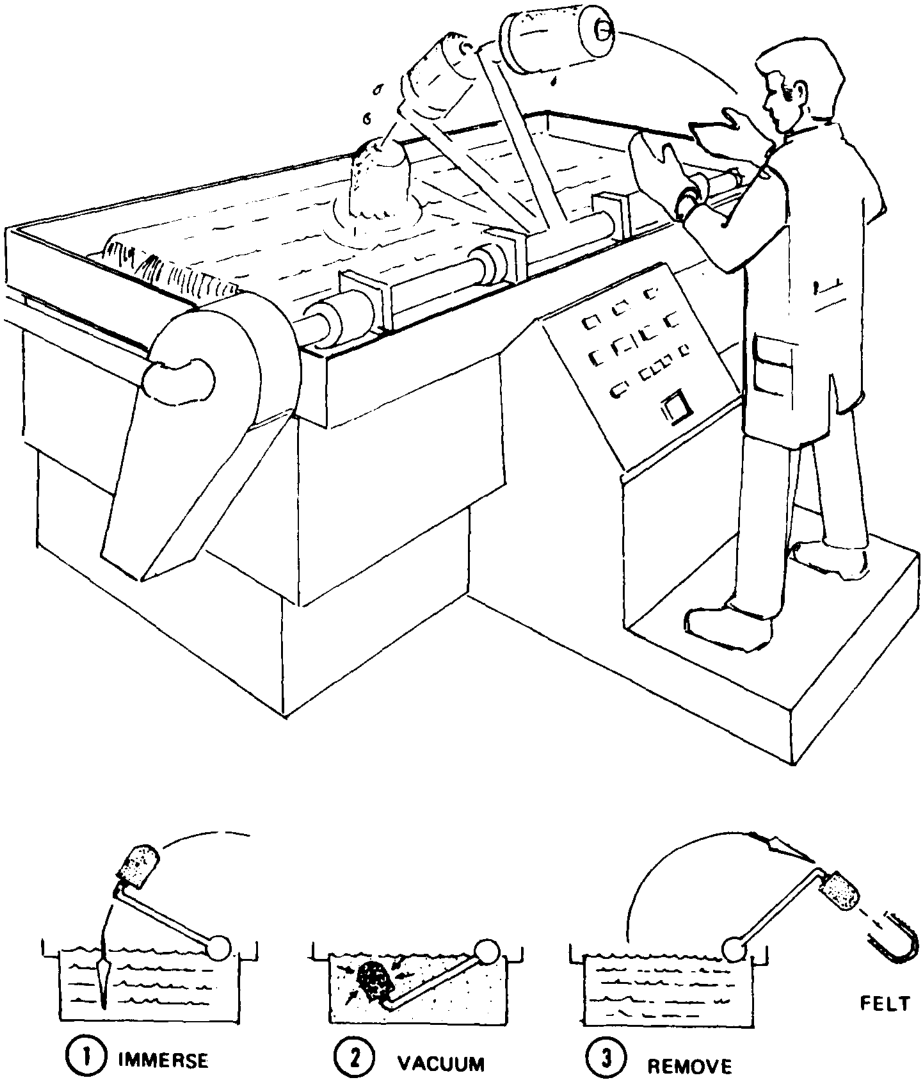
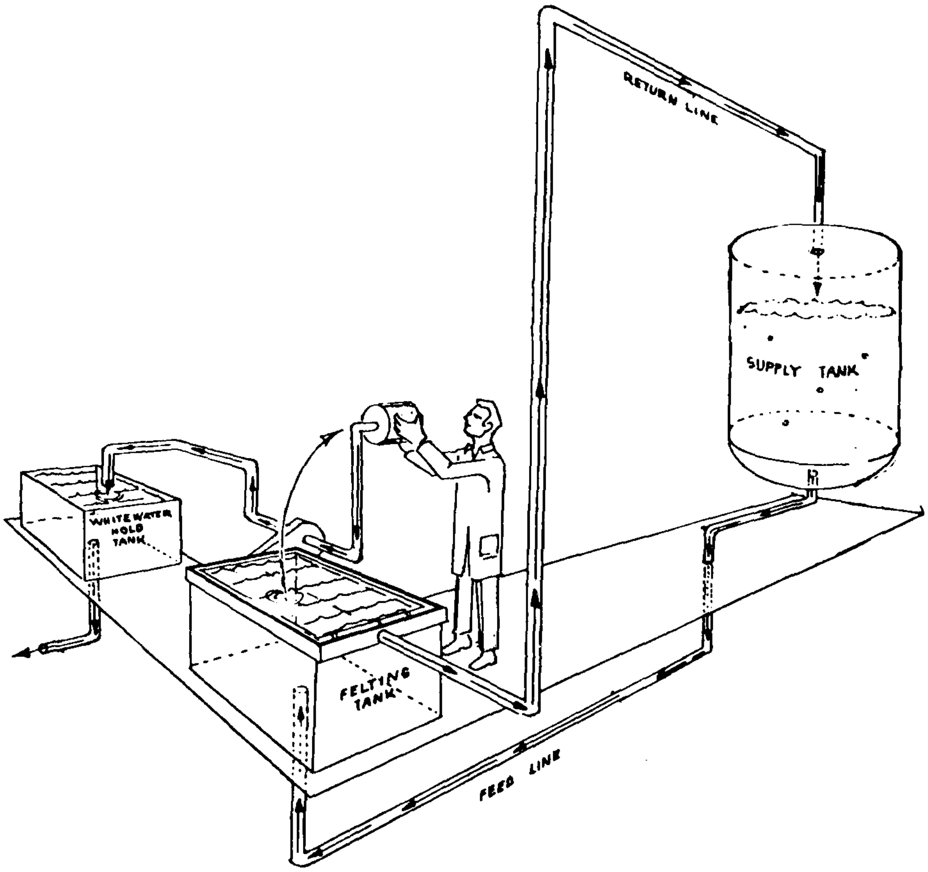


Figure A-3. Felting

The felting tank is rectangular. The slurry input is from the bottom center with a rectangular baffle, mounted to give a 1/4-inch opening or slot between the baffle and the tank bottom; thus diffusing an equal amount of slurry in all directions. The felting tank is allowed to overflow equally over a weir and into a return trough on all four sides. This is designed to give the best possible distribution of the slurry mixture within the felting tank (fig. A-4).



NOTE: VALVES AND PUMPS OMITTED FOR CLARITY

Figure A-4. Felting flow system

Molding

The wet felt is dewatered and cured by a predetermined molding cycle in the steam-heated (250°F) matched metal dies. The male section of the die contains vertical grooves, closely spaced on the die face. These grooves are connected to a manifold at the base of the male die. The manifold is connected to the vacuum source.

Dewatering is effected in two steps. First, the free water is literally squeezed out through the vacuum grooves during the die-closing operation. The remaining moisture is then vaporized by the die heat and is vented through the vacuum grooves.

The resin is cured during the closed-die cycle (which is approximately 3 1/2 min.). The dried part is ejected from the male face by compressed air via the vacuum manifold and grooves (fig. A-5). The finished combustible cartridge case for the 152-mm conventional ammunition is shown in figure A-6.

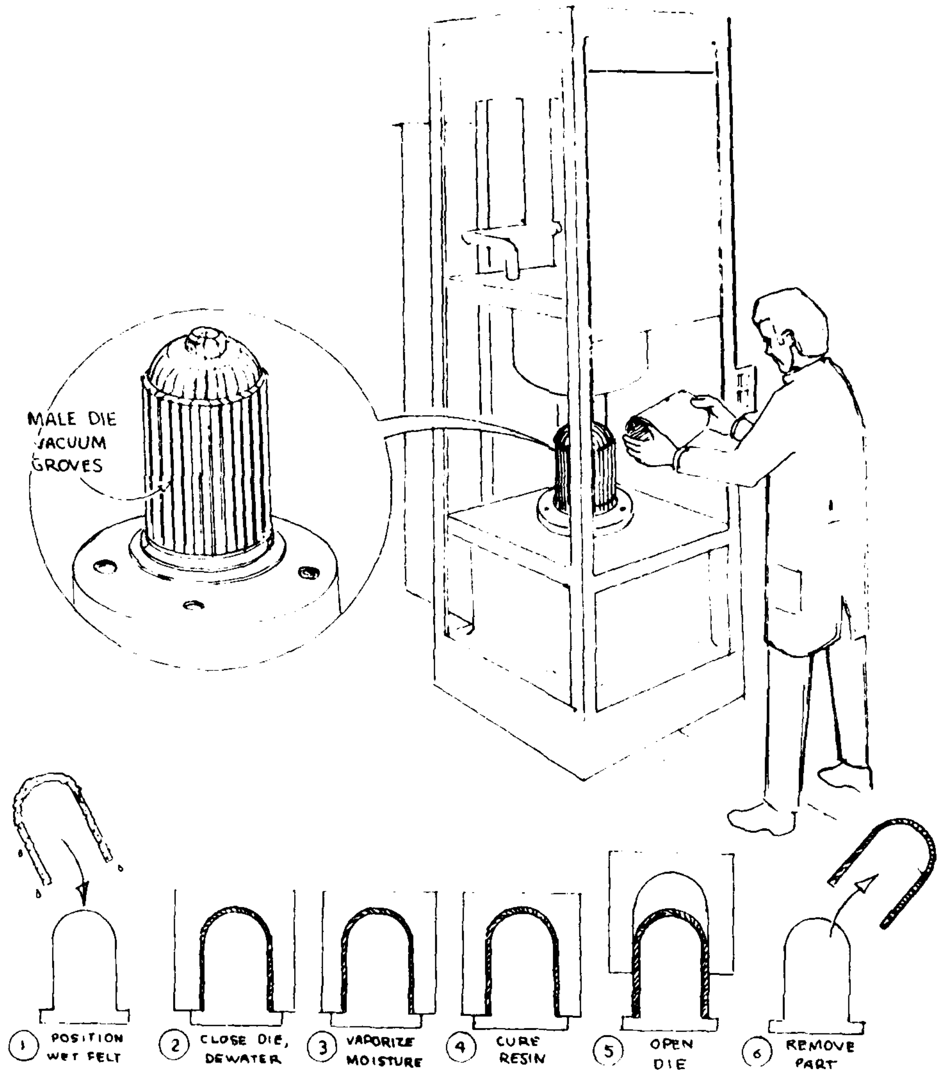


Figure A-5. Molding

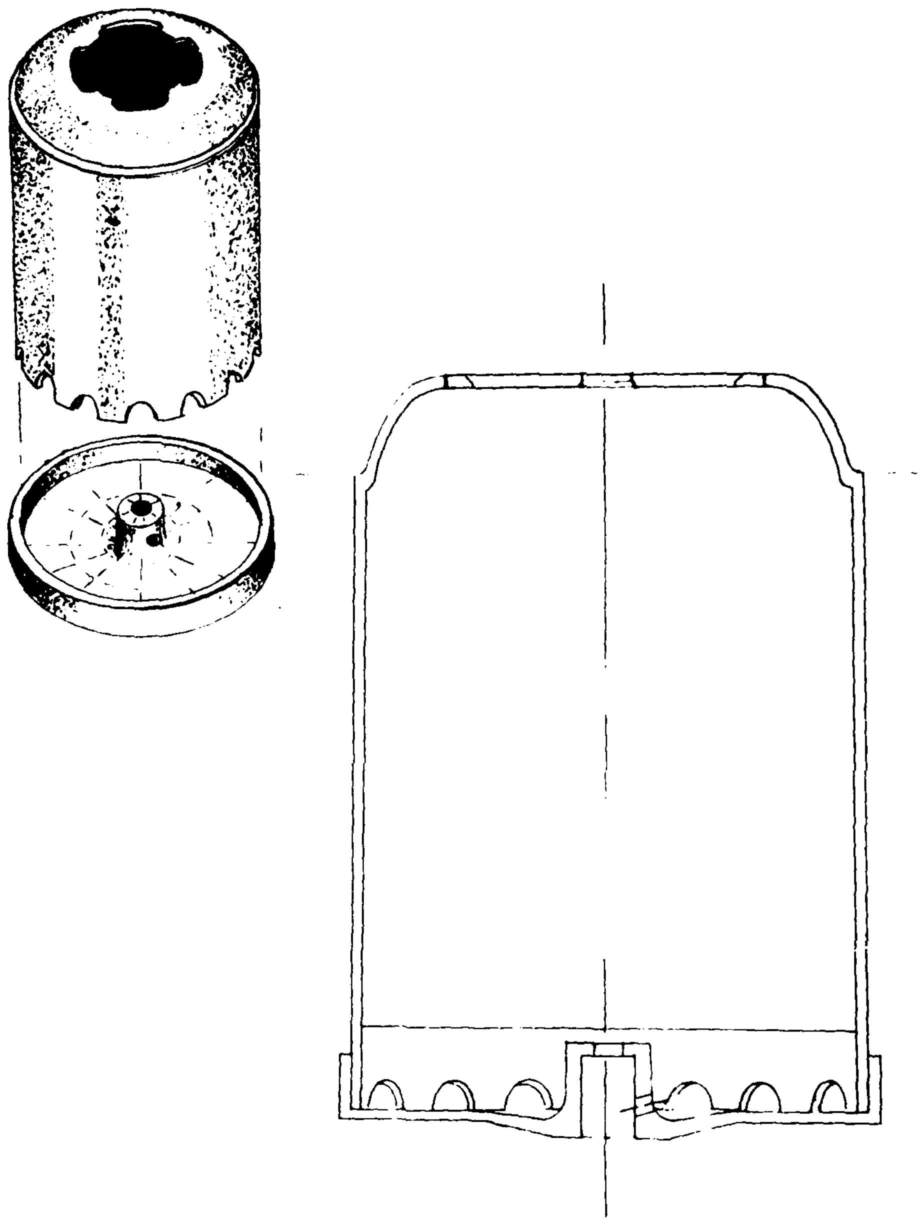


Figure A-6. Test configuration of 152-mm combustible cartridge

APPENDIX B

DESCRIPTION OF DEFLAKER

undated 14a/3

SPROUT, WALDRON & CO., INC.
MUNCY, PENNA.

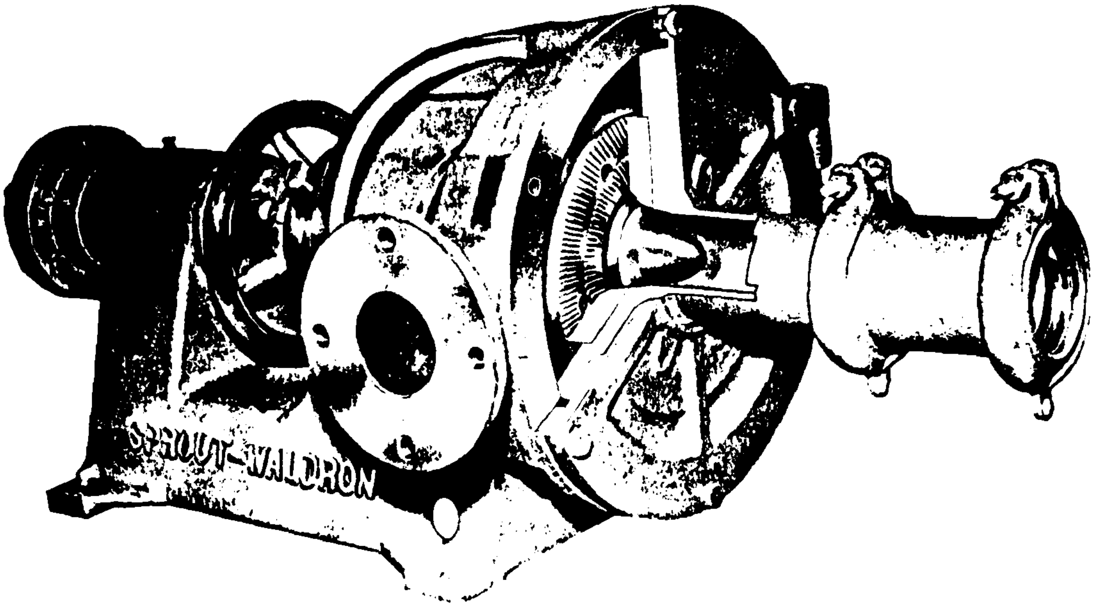
SINCE 1866

ADVANCE SPECIFICATION SHEET

No. 250

MODEL DF-9

DEFLAKER



The Sprout-Waldron pressurized deflaker is designed to separate fiber bundles - and does so without significant change in stock freeness.

Flexibility in operation is a principle advantage of the Sprout-Waldron deflaker. The design permits plate clearances to be adjusted without shutting down the unit when changes in throughput or degree of deflaking are necessary.

OPERATION

Stock enters the deflaker through a horizontal inlet connection on the center of the swing door. The stock is deflaked as it passes between stationary plates mounted on the door and plates mounted on the rotating disc and is discharged through an outlet on the side of the deflaker shell.

Plate adjustment can be made while the deflaker is running by turning the hand wheel. This action places pressure on the outer race of the thrust bearing and causes the entire shaft and rotating disc assembly to move to the desired clearance. A plate position indicator is provided.

The deflaker is powered by a direct coupled motor of up to 75 horsepower at 3600 rpm.

The plate diameter is 9". A variety of patterns, each designed for the degree of deflaking required, is available.

CONSTRUCTION

The design incorporates a heavy cast iron base complete with bearing pedestals and runner head casing support which are cast integral and line bored.

A water-lubricated packing gland and stainless steel shaft sleeve with ceramic insert is provided.

Bearings are of the heavy-duty, anti-friction grease lubricated type, and are protected from entry of dust and chemicals.

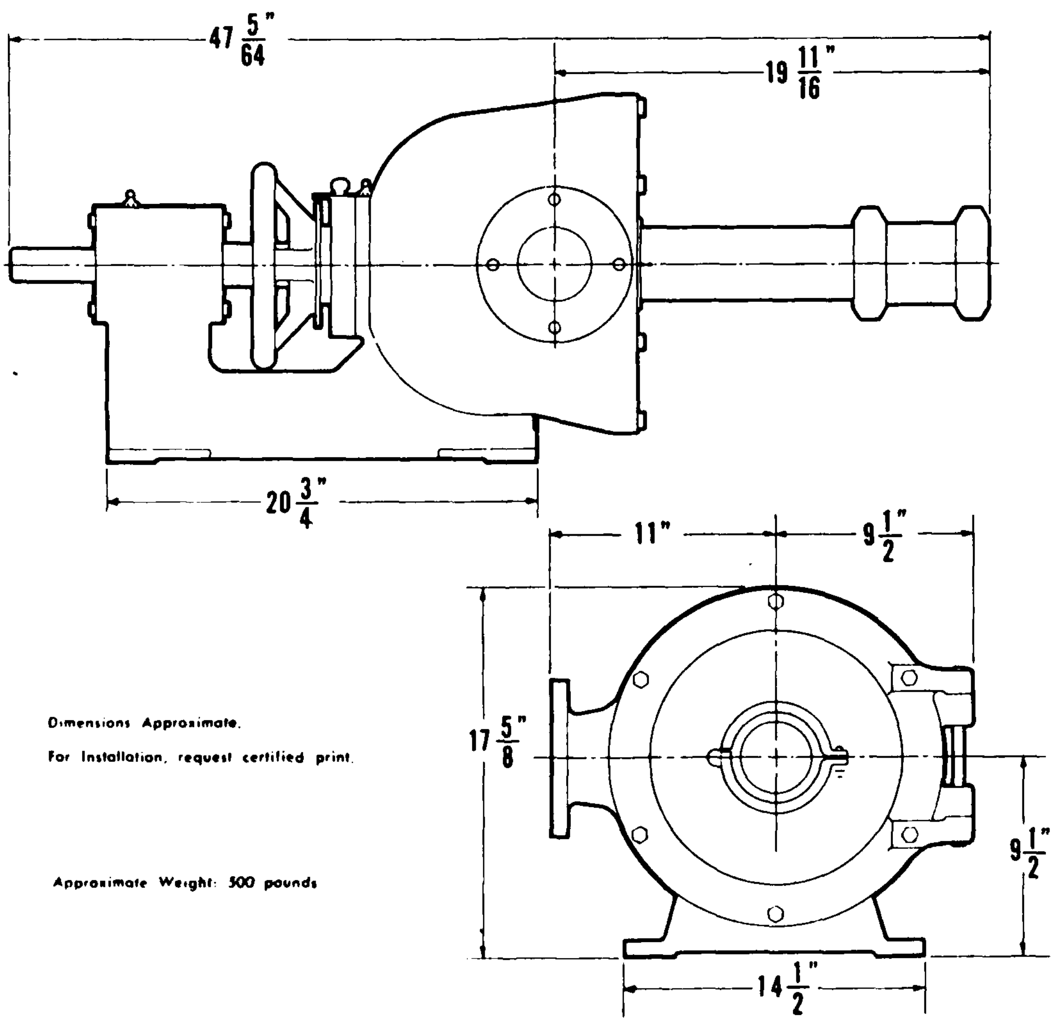
The swinghead which holds the stationary plates seats itself on a machined surface of the casing. The use of a quick-opening pipe joint at the stock inlet permits fast access to the deflaking area for inspection and plate changing. Normal time for plate change is 15 minutes.

For acid resistance, all parts in contact with process liquors are of stainless steel with the exception of Ni-hard deflaking plates.

CAPACITY

A maximum throughput of 40 TPD at 3½% consistency is attainable with the Sprout-Waldron deflaker.

DIMENSIONS:



Dimensions Approximate.

For Installation, request certified print.

Approximate Weight: 500 pounds

DEFLAKER

In designing the Sprout-Waldron Deflaker, our goal was to design a reliable, competitively priced deflaker that offered features not available on competitive units. It is designed with all wetted parts of 304 or 316 SST.

Let's take a look at a cross section of the machine. The Deflaker is basically a single disc pressurized machine. Deflaking plates are mounted on one side of the Rotating Disc with the stationary plates mounted on the inside of the swing door.

The rotating assembly consists of disc, shaft and bearings. The shaft is fitted to the disc with a tapered fit and key. After the disc is placed on the shaft, a cap nut is turned on the threaded end of the shaft, tightened, and tack welded to hold the disc in place. The disc is 304 or 316 SST while the shafting is of carbon steel.

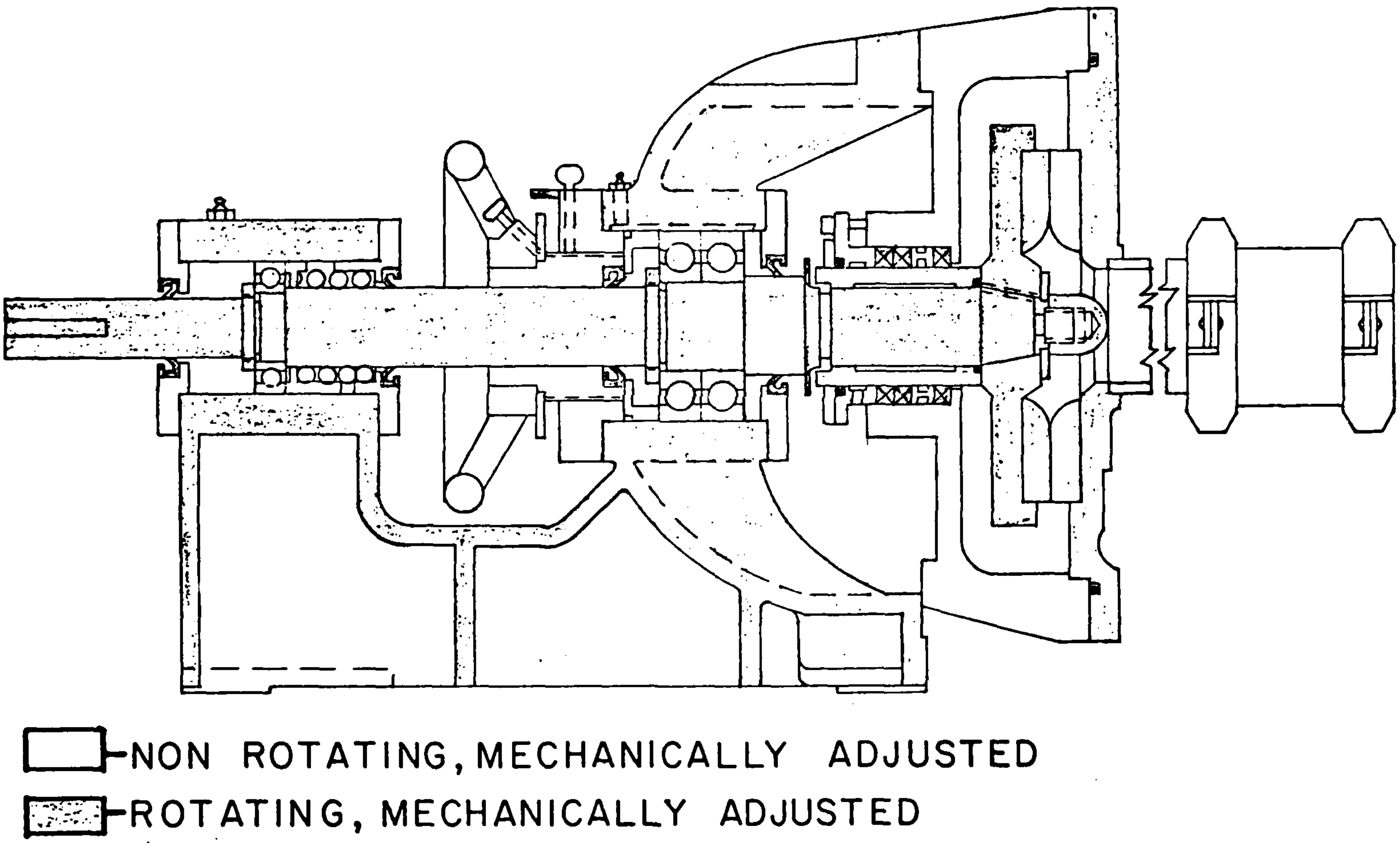
Behind the disc is a ceramic coated shaft sleeve for the packing to run on. The fit between the sleeve and shaft is an interference fit, the sleeve is heated and slipped on the shaft. An "O" seal is used between sleeve and disc to protect the shaft.

The front pair of bearings in the Deflaker is mounted in tandem to carry thrust in one direction only. These bearings have bakelite cages and are grease lubricated for 3600 RPM operation.

The back bearing is a standard super conrad ball bearing and is grease lubricated too.

The Sprout-Waldron Deflaker has a plate clearance

adjusting mechanism controlled by a handwheel. With this handwheel it is easy and convenient to adjust plate clearance while the deflaker is on the line. At the time the Sprout-Waldron Deflaker design was completed, this feature was not available on competitive units. I think this is still true.



ASSEMBLY 9" DEFLAKER

The design of the handwheel adjustment is similar to the design of the mechanism used on the Sprout-Waldron 12" Model 105-A Lab Refiner.

Let's take a look at how this mechanism actually works. Bolted to the back of the front bearing pedestal is a plug with internal threads. The handwheel is attached to a sleeve with external threads. As the handwheel is turned clockwise, facing the handwheel from the rear of the machine, the handwheel sleeve contacts a spacer which pushes from the rear against the outside race of the thrust bearings. Since the inner race of the two thrust bearings is held against the shaft shoulder, the shaft and disc assembly move forward to reduce clearance between the rotating and stationary disc.

To increase plate clearance, the handwheel is rotated counterclockwise which releases pressure on the thrust bearing. The compression spring located in the rear bearing pedestal exerts force to cause the shaft and disc to move back with the handwheel sleeve.

The small springs in the front bearing pedestal are to insure that the front thrust bearings always have a thrust load in one direction.

The thumb screw located in the internally threaded plug bolted to the back of the front bearing pedestal is used to lock the handwheel sleeve after the plate clearance has been set.

Note that the lip seals are arranged to exclude dirt and water and to let excess grease escape from the bearings.

The process chamber consists of two stainless castings, the shell and swing door. Both are designed for 100 psi maximum pressure. The shell is attached to the cast iron Deflaker base by three bolts. The swing door is fitted to the shell via a pilot fit to assure alignment and held in place by six 1/2" bolts.

The packing gland is cast and machined as part of the shell. The packing follower is split so that it can be removed to make access to the gland convenient. We use the same packing in the deflaker that we use in the Twin-Flo Refiners. (Hercules 91040W)

Stock enters the deflaker through the center of the swing door and travels outward between the plates and exits through the side of the shell. A standard 150 pound pipe flange is cast and machined on the discharge.

On the inlet of the deflaker we supply a "Marman" Aeroquip Flexmaster quick disconnect pipe coupling to connect to the customers plain end stock feed line.

For plate changing, two bolts are loosened on each end of the Flexmaster coupling and the coupling is slid back towards the swing door. The six bolts holding the swing door to the shell are removed and the swing door opened to expose both sets of deflaking plates. Plate changing requires less than 15 minutes; another desirable feature over competitive units.

In order to deflake stock without refining it, the deflaker is operated normally with a plate clearance between .010 and .025.

We have tried to utilize a combination of two methods of deflaking in the Sprout-Waldron Deflaker and deflaker plates. The first method used is based on designing the plates so as the stock passes through the plates, the flakes or specks are mechanically broken down into smaller particles by contact with the plates. The second method used is based on agitating the stock violently enough to have the particles torn apart by hydraulic shear.

Since the deflaker is operated with a plate clearance and the plates are designed to produce hydraulic shear as well as mechanical, we have virtually eliminated the possibility of increasing stock pressure as the stock passes through the deflaker. Our experience with plates tested to date indicates that plates which produce effective deflaking also cause a pressure drop of 15 to 25 psi across the deflaker. The drop is also dependent on flow rate. Since the thrust bearings do have a limit, it is recommended that we limit stock inlet pressure to a maximum of 60 psi and a maximum pressure drop of 25 psi. If the pressure drop is more than 25 psi, the flow through the deflaker can be decreased with a throttle valve.

No load horsepower for plate patterns tested to date for various stock pressures and consistencies have ranged from 35 HP to 50 HP. The Deflaker was designed for a maximum of 75 HP at 3600 RPM.

The inexpensive, removable deflaking plates are another feature of the Sprout-Waldron 9" Deflaker.

DEFLAKER PIPING

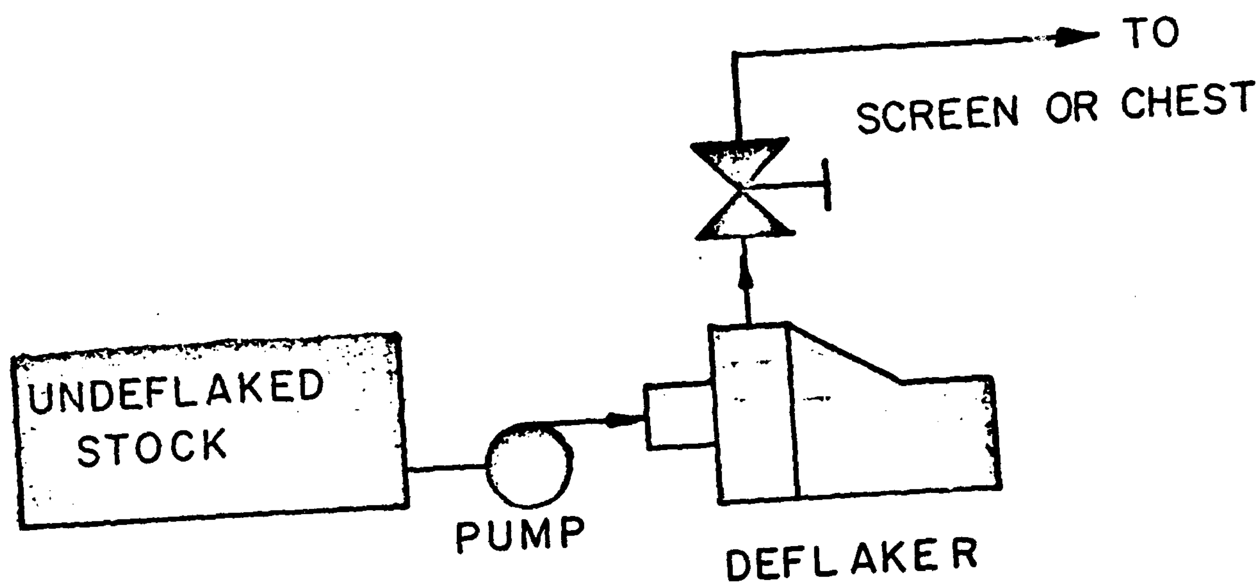
Since the Deflaker is a pressurized pump through unit, the design of the process piping system is similar to that required for a Twin-Flo.

The First Schematic shows a very simple deflaking system. Shown is a pump to feed the deflaker under pressure and a throttle valve on the discharge which is used to control flow rate and to keep the system submerged or flooded at all times.

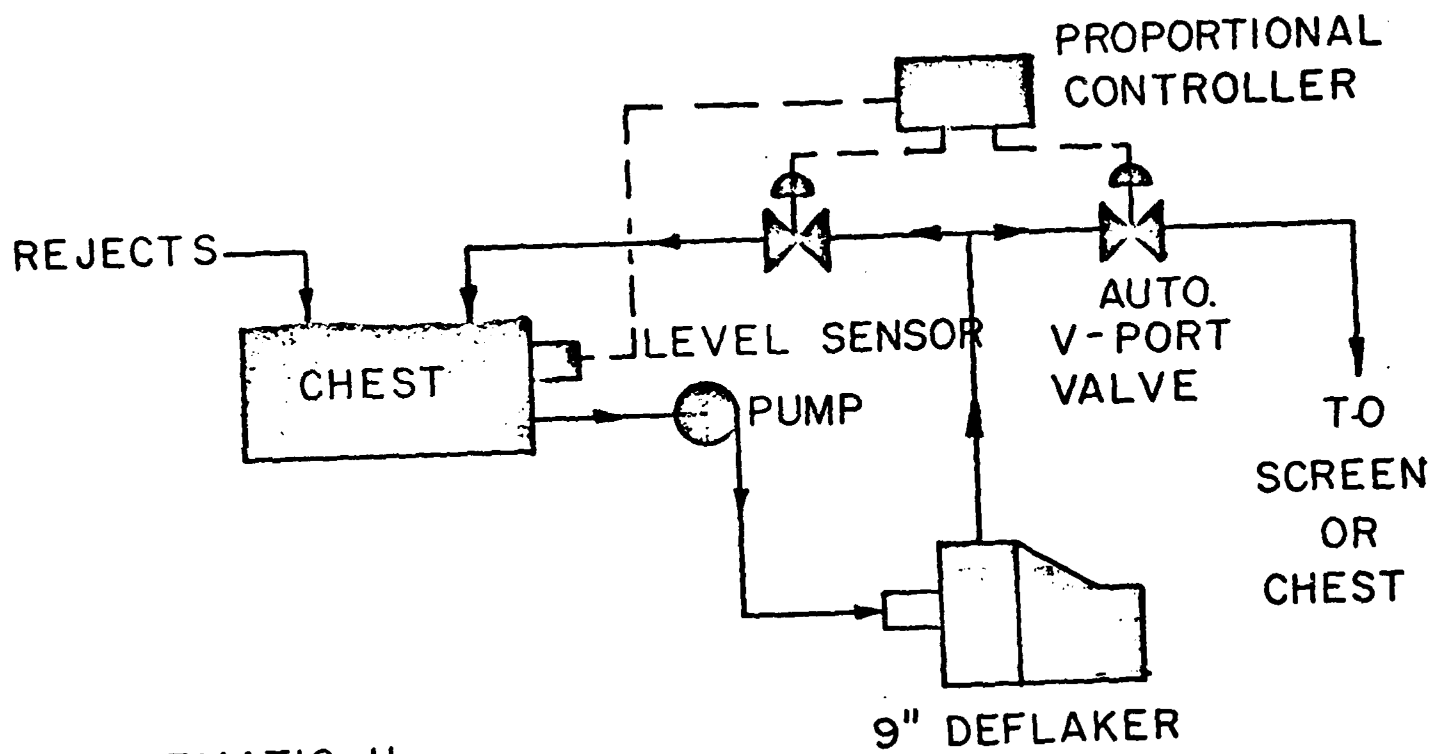
Schematic II is an example of a rejects deflaking system with the type of controls necessary for the system to function properly.

As we all know, few screening systems discharge rejects at a constant rate, thus we show a chest for accumulation of rejects so that the pump can feed the deflaker at a constant rate. We have a recirculation line back to the chest. If the chest level starts to fall, the chest level sensor and Proportional controller would partially close the control valve in the Deflaker discharge line and partially open the control valve in the recirculation line to maintain chest level.

If the chest level starts to build up, the controls would work in the reverse allowing more stock to discharge from the system to maintain chest level and flow through the Deflaker.



SCHEMATIC I



SCHEMATIC II

REJECTS DEFLAKING

SPROUT-WALDRON 9" DEFLAKER

Sprout-Waldron's latest new product line being offered to the Pulp & Paper Industry is the 9" Deflaker and five (5) units are presently in the field. The first unit was installed at Container Corporation in Philadelphia and has been in operation on an almost continuous basis the better part of a year. This particular deflaker is being used to defiberize primary screen rejects. The furnish is mixed waste paper of about 30% corrugated and 70% mixed papers consisting mainly of news, magazines, office waste, etc., which is used for filler stock for folding board. A slide will be shown to cover the details of this system.

The second unit to go into operation is located at the Simpson Lee Company in Vicksburg, Michigan. This unit was actually set up on a temporary basis for research purposes. A number of tests have already been concluded, some being successful and some being not so successful, but there are many more tests to follow in the near future. This deflaker follows a batch pulper and the object is to shorten pulping time while producing a nib free furnish. A variety of broke is processed such as photo base, blueprint base, overlay, and many types of fine papers. Kraft and sulphite constitute a large percentage of the furnish but cotton fibers are also used extensively. To complicate matters, many of the broke grades contain wet strength additives which, of course, complicate the slushing and deflaking process. The deflaker is pump fed and the piping is so arranged that the stock can be re-cycled back to the pulper for a multi-pass operation or pumped from the deflaker on to the broke storage chest.

This installation does offer the possibility of experimentations on a great variety of broke furnishes and hopefully, we will have the manpower and the time to witness and to take part in these experiments.

Three (3) other deflakers are in the process of being installed and should be started up in the very near future. One of these will be at Westvaco in Tyrone, Pennsylvania where they plan to deflake coated paper broke at the rate of about 30 TPD. Another unit is being installed at Kimberly-Clark at New Milford, Connecticut and this application will be the deflaking of tissue broke. The final installation will be starting up at Georgia-Pacific in Crossett, Arkansas.

DEFLAKING

Deflaking, or perhaps a better word would be Fiberizing is the process of separating fiber bundles without cutting or hydrating or at least accomplishing very little cutting or hydrating with a very minimum of freeness drop.

All deflakers are very high speed units and the working principle of fiber length preservation and no hydration taking place is based on the principle of very high impact forces combined with intensive fluid shear. Refining on the other hand requires a high degree of bar to bar surface area and the fibers are squeezed and bruised in the process of passing over the bar surfaces. Cutting is best accomplished by a very high degree of bar loading which in effect cuts the fibers as they attempt to enter over the surface of the bars. Deflaking clearances on the other hand are held depending on the stock being processed to a definite clearance which will allow the fibers and fiber bundles to pass without any squeeze on the fibers. Violent turbulence must accomplish the separation which is not enough to damage the individual fiber structure.

There are about five general areas where deflaking has found wide spread use.

1. Waste paper.

   The widest application is generally in waste paper handling. A batch pulper will slush the waste until it can be pumped to a deflaker. The pulp can be re-cycled back to the pulper for a multi-pass operation or pumped directly to process. De-inking which is simply thorough dispersion of the printers' ink is an excellent deflaker operation. It can be readily seen that deflaking in conjunction with pulping can reduce the pulping cycle by as much as 75% and result in drastic power savings as well as accomplishing a much better deflaking job overall.

2. Repulping Broke.

   Repulping Broke is essentially the same situation as handling waste paper. It is generally an easier operation because the paper is fresh off the machine and devoid of foreign material usually associated with waste paper repulping.

3. Wet Strength

Deflakers are especially useful in the slushing of wet strength papers and in fact can often accomplish the job of successfully slushing the paper where on occasion, it would be virtually impossible to do so in a pulper alone. If a pulper can accomplish the flushing operation by itself, certainly a deflaker will drastically cut down on the time required and, of course, greatly lower the overall horsepower requirements.

4. Tissue Stock

This application is gaining ever increasing attention. Tissue Broke is a very soft and easily dispersed furnish which usually can be completely fiberized without any subsequent refining. Refining is to be avoided if possible, because fiber length is very short. Minimal treatment as produced by deflaking is usually sufficient to eliminate all fiber bundles. Deflaking only is said to produce softer tissue with better formation, without further treatment.

5. Screen Rejects

Deflakers are being used for this application in both pulp and paper mills. Apparently, sufficient fiber separation is being accomplished so that when the rejects are returned for re-screening, a significant drop in shrinkage occurs due to screening and cleaning without sacrificing produce quality.

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